JPRS-CST-86-035
2 SEPTEMBER 1986

China Report

SCIENCE AND TECHNOLOGY

FBIS FOREIGN BROADCAST INFORMATION SERVICE

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

PROCUREMENT OF PUBLICATIONS

JPRS publications may be ordered from the National Technical Information Service, Springfield, Virginia 22161. In ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited.

Current JPRS publications are announced in Government Reports Announcements issued semi-monthly by the National Technical Information Service, and are listed in the Monthly Catalog of U.S. Government Publications issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Correspondence pertaining to matters other than procurement may be addressed to Joint Publications Research Service, 1000 North Glebe Road, Arlington, Virginia 22201.

JPRS-CST-86-035
2 SEPTEMBER 1986

CHINA REPORT
SCIENCE AND TECHNOLOGY

CONTENTS

PEOPLE'S REPUBLIC OF CHINA

ABSTRACTS

TAIWAN

HONG KONG MEDIA ON CHINA

/9986

TETRACYCLINE HCl ANTIBIOTIC ATTAINS FIRST-RATE STATUS

Shanghai JIEFANG RIBAO in Chinese 26 May 86 p 1

[Article by Zhu Peiren [4376 1014 0088], correspondent, and Gao Xiaoxiao [7559 5135 4562], reporter]

[Text] A tetracycline HCl product from China has been hailed as a first-rate antibiotic on the international market. Called "China Yellow" because of its characteristic yellow coloring, it has become a hot export item for China. Its scattered production in 16 different provinces and municipalities, and export through a multiple port set-up in the past has now been converted to a joint operation of consolidating exports through the port of Shanghai, which has led to a gradual rise in foreign exchange. At the recent Guangzhou Trade Fair the sale of "China Yellow" was negotiated at a favorable price, but supplies were not adequate to meet demand.

"China Yellow" is an export item marketed by the Shanghai Pharmaceutical Health Products Import and Export Corporation. Manufactured early on by the Shanghai Pharmaceutical No 3 Plant, it had broken into the international market in the early 1960's. Because of its high quality and unusual characteristics, it was highly rated by foreign businessmen. The general manager of the pharmaceutical section of one of the world's largest chemical companies had conducted a chemical analysis of "China Yellow" and concluded that its quality exceeded not only specifications set down in the BRITISH PHARMACOPEIA, but also that set by countries of eastern Europe.

In recent years, the pharmaceutical industry throughout China underwent new changes and development, and several scores of pharmaceutical plants were built to manufacture "China Yellow." But their scattered distribution through 16 export companies dispersed in Shanghai, Tianjin, Guangxi, Sichuan, Shenxi, etc., led to a competitive situation in promoting "China Yellow," with price wars and bid undercuttings. "When the sniper and the mussel fight each other, only the fisherman profits" could be used to describe this state of affairs. Because of competition between these export companies, the original favorable marketing climate for "China Yellow" was weakened, and a situation was created where this drain of "liquid riches" was directly affecting the accumulation of foreign exchange. According to statistics for the period 1978-83, the production volume of "China Yelllow" continued to rise, but its export value continued to drop; the increased

foreign exchange that accumulated from an increased export volume was canceled out by a corresponding price drop in the commodity.

This critical situation caused the various export companies to explore a unified approach to export problems. In early 1984, the 16 import and export companies had a meeting in Beijing organized by the leadership of the parent corporation, and unanimously selected the Shanghai company as the export agent to consolidate all exports into a joint operation on the national level. Thus, a new approach was devised for a unified export policy known as multiple port commodity consolidation.

In this joint export venture, the role of the agent company is to centralize and regulate commodity supply, to consolidate export operations, and to determine the distribution and returns of foreign exchange on the basis of actual volume exported. Consequently, the multiple port companies have become cooperating partners, instead of competitors, in a joint enterprise. The local companies can concentrate their efforts in organizing and improving their supply network to assure timely product delivery. On the other hand, the agent company can concentrate on survey studies and timely information gathering to help complete transactions geared to the needs of the international market, at maximum returns on maximum export volume, which will effectively prevent this drain of "liquid riches." Since this joint export venture became operational, the accumulation of foreign exchange has been building up gradually. At present, the export value of "China Yellow" has seen a 10 percent increase over that before the joint venture was instigated and has turned around a 6-year price decline. [Editor's note: According to the 1985 Almanac of China's Foreign Economic Relations and Trade, China exported 680,929 kg tetracycline HCl valued at $14,670,000 and 979,948 kg valued at $17,860,000 in 1984 and 1983, respectively.]

When this joint export venture became a reality, the threat of a watered-down product that had surfaced momentarily was also controlled. Its underground source of supply was plugged, so that the export value of "China Yellow" would not be adversely affected. Since last year, product quality of "China Yellow" has been enhanced 10 percent.

Now that this consolidated approach to exports has been initiated, some foreign businessmen who are marketing "China Yellow" are doing very well. In the past, they had to deal with 16 multiple-port companies. Now, they need only to go through the Shanghai agent company: The trading channel is smooth, delivery date is guaranteed, product quality is assured, the price is reasonable, and business confidence is strengthened. At present, the sale of "China Yellow" on the international market is not only stabilized, it has also developed new markets in countries such as Great Britain, the Federal Republic of Germany, Switzerland, Belgium, Thailand, the United States, etc., and Hong Kong.

5292/13046
CSO: 4008/1083

BEIJING EXHIBIT FEATURES TV EQUIPMENT

OW021252 Beijing XINHUA Domestic Service in Chinese 0855 GMT 27 Feb 86

[Text] Beijing, 27 Feb (XINHUA)--Silvery ROSET antennas facing the blue sky and clear TV programs relayed by international satellites in orbit above the equator could be seen projected on televisions and color monitors. An exhibition of a satellite television ground station and its related equipment being held in Beijing shows that China's electronics industry is capable of supplying sets of equipment for receiving TV programs from satellites and that China is ready to open a satellite educational TV channel on 1 July.

Electronics enterprises have now begun to mass-produce satellite TV receivers, relaying, program-producing, and transmitting equipment. Since China began broadcasting TV programs via satellite in October last year, the Ministry of Electronics Industry has supplied the nation's 29 provinces, cities, and autonomous regions with nearly 200 sets of satellite TV receivers and has begun to export this type of receiver. To meet the need of promoting education through televisions, the Ministry of Electronics Industry has made special efforts to develop a shunt system which enables a single antenna to simultaneously receive the comprehensive program of the Central Television Station and four other programs including the educational channel. After viewing the equipment at the exhibition, a responsible comrade of the State Education Commission, said: "The satellite TV receivers supplied by China's electronics industry are reliable and cheap and basically meet the need of developing education through television. It seems that it is no longer necessary to import this type of equipment on a large scale."

It has been learned that China will vigorously promote television education throughout the country during the Seventh 5-Year Plan period. In addition, China will also open more satellite TV channels for other purposes. Therefore, satellite television ground stations and related equipment will have a wide market.

/9738
CSO: 4008/1105

NI ZHIFU VIEWS RESEARCH FINDINGS EXHIBITION

SK020858 Tianjin TIANJIN RIBAO in Chinese 20 Apr 86 p 1

[Text] Yesterday morning, Ni Zhifu, secretary of the municipal CPC Committee, watched an exhibition on the achievements in software research for key scientific and technological development areas during the "Sixth 5-Year" Plan period, and fully affirmed the software research work of the municipal Scientific and Technological Commission.

He said: It is correct for the municipal Scientific and Technological Commission to pay attention to grasping the strategic issue of developing and conducting research on software for the macroeconomy. This commission has served as an adviser to the municipal CPC Committee and government while working out policy decisions. With regard to the development of natural resources in Jixian County. Comrade Ni Zhifu said: Jixian County has great potentials because it has mountains and bodies of water. We should make our given circumstances. The municipal Scientific and Technological Commission should use science and technology to support Jixian County and exert more efforts with regard to the area. While watching an exhibition on the survey of natural resources in the coastal area, Comrade Ni Zhifu said: it is very important to develop the Bohai economic zone. Tianjin should not give consideration to the problems of a city only. It should promote more regional cooperation and joint development. While developing our municipality, we should also support other localities. It is impossible to become self-supporting in everything.

/9738
CSO: 4008/1105

DISCUSSION OF TECHNOLOGY MARKET ISSUES

Beijing KEYAN GUANLI [SCIENCE RESEARCH MANAGEMENT] in Chinese No 1, Jan 86 pp 73-75

[Article by Chen Wenhua [7115 2429 0553], Peng Yiduo [1756 0001 1122] and Jiang Shihe [5592 0013 0735]: "A Discussion of the Technology Market Issue"; first paragraph is KEYAN GUANLI introduction]

[Text] Editor's note: Reforms in economic and scientific research systems have developed in a comprehensive manner in recent years and technology markets for the exchange of scientific and technical commodities now are appearing. The development of technology markets is playing an important role in science and technology and in economic construction in China, but several problems have appeared during the developmental process that require theoretical and practical solutions. KEYAN GUANLI has taken some excerpts from drafts we received concerning this question that we are providing as references for our readers to use during research.

I have some ideas on opening up technology markets:

1. We must change outmoded ideas that scorn business, and we should permit and encourage S&T personnel to handle technical commodities. Technical commodities are a type of commodity, so the development of technology markets naturally will lead to the appearance of specialized new professions in activities related to the management of technical commodities. These new professions and their agents are still in their infancy in China. We should permit and encourage some S&T personnel to handle technical commodities whether under administration by the whole people, collectives or even individuals. We should provide moral support for them in all of their normal activities and grant them legal protection.

2. Strive to develop diverse organs to manage technical commodities, strengthen circulation links and promote the intermediary role of technology markets.

To accelerate the commodification of technologies, in addition to the dissemination of technologies and circulation of technical commodities through "technology trade fairs," "technical consulting service companies," "technical development centers" and other forms of organization, I propose that enterprise-type technology bazaars (stores) and markets be set up in cities and that technical commodity retail outlets be set up in rural supply and marketing cooperatives.

These technology markets can be of the "department store" type, or they can be specialized or even confined to a single item. These technology markets should focus on management of technical commodities and they also can serve as intermediaries between the relevant manufacturing plants and users by functioning as suppliers of technical commodities to play a role in transmitting information and promoting the rapid conversion of technological achievements into forces of production. Consideration can be given to a unique system for these new professions. Technology management departments should be set up in provinces, prefectures and counties or former technology extension organizations can be converted to technology market organs to strengthen leadership or professional guidance.

3. Strengthen research on "technology management" and focus on training people who are good at handling technical commodities.

Technology is a commodity that exists independently in the form of knowledge. Technology markets are special kind of markets that are much more complex than normal markets. Technology management is a new discipline. Administration of technologies and management of their markets requires a large number of people with specialized skills who are good at administration. S&T personnel at present, however, lack administrative and managerial abilities, while those who are good at business do not understand science and technology (especially modern S&T). For this reason, there is an urgent need to create an intersecting discipline that we can call for the present "technology management." In addition, I propose that we take action to organize forces to develop research on "technology management," prepare teaching materials, convene specialized academic symposia and set up short training courses. Institutions of higher education with the proper conditions should establish "technology management" specializations or set up relevant courses for undergraduates.

Chen Wenhua; South China College of Metallurgy

I have some views concerning the collection of fees for technical transfers:

Intensive development of reforms in urban and rural economic systems in recent years has created a high tide of technical transfers. S&T and scientific achievements take something that is not very valuable and increase its value a hundredfold, a full 180 degrees turnaround that is very gratifying. We cannot, however, allow our gratitude to obscure the affects of unhealthy tendencies in society and the fact that the costs of some technical transfers are a bit too high. Some blueprints from the 1950's, for example, are being redried and then sold for 1,000 yuan. One group of design blueprints costs more than 30,000 yuan and they wanted profits and dividends for 3 to 5 years. In some areas, S&T achievements and S&T transfers are passing through the hands of two or even three dealers, with each level skimming profits as if they were some scarce good purchased on the black market. If this continues for any period of time, it will have negative effects on the development of urban and rural enterprises. It will not be good for the development of backward regions or the extension and utilization of S&T achievements, and it will also be bad for the modernization drive.

To benefit the development of backward regions and economic prosperity in urban and rural enterprises, a great deal of consideration and study should be done concerning ways to deal correctly with the question of transferring S&T achievements. The relevant departments should meet with the relevant specialists and scholars to draw up several grades for S&T achievements (including new products, new materials, new technologies and so on) and establish fee standards for technical transfers according to grade. We can copy the management method used by commercial departments to unify pricing policies. Units that transfer their achievements can submit them to the state or province for examination and approval of the grade, after which they can be announced for public transfer. This would permit us to avoid a situation in which everyone sets their own prices, raises prices and speculates, and it also would benefit management and scientific and technical progress and have positive effects on development of the forces of production and economic prosperity.

How should the standards for S&T achievements be determined? At present, we should be concerned with the law of value and we cannot ignore our national situation. Suitable transfer fees should be adopted with a prerequisite of making greater contributions to the state, being concerned for the prestige and ethics of units and individuals, developmental assistance and so on. Especially important is that preferential treatment should be given to county as well as township and town enterprises. Furthermore, can there be a formula for fee standards for technical transfers? This is another issue that deserves discussion.

Transfer of scientific research achievements and technologies is a good thing. To assure healthy development of work in this area and allow S&T achievements to play their inherent roles as quickly as possible, it is extremely important that we study the question of examining and revising fee collection standards for technical transfers.

Peng Yiduo; Hunan Province, Xiangxiang County Science Association

The main issues that appear during the process of technology market development:

1. The special nature of technical commodities.

First, technical commodities are commodities that exist in an intangible form and are unquantifiable. They generally take the form of blueprints, materials, models and so on, and they also can take the form of oral instructions and operational demonstrations. It is only possible to use the results of technical commodities after they are utilized, such as calculations based on the development of new products or improvement in production conditions. Second, technical commodities can play their roles only after they are materialized, and the materialization of technical commodities requires certain conditions. For this reason, there is a certain amount of inaccuracy and risk involved in technical commodities. Third, the trade in technical commodities often involves only the transfer of the use rights over the technology as well

as the manufacturing and selling rights for the corresponding products. The buyer can obtain the actual content of the technology but does not obtain ownership over the technology as a result. Fourth, technical commodities can undergo multiple transfers without a need to be repeatedly reproduced. Because the production of technical commodities involves innovation, exploration and non-repetition, it often happens that only those technical commodities with the lowest production costs and greatest economic benefits are accepted by society and thereby achieve their value.

2. Prices for technical commodities.

The special nature of technical commodities is a direct cause of a series of special questions related to the price structure of them. The essence of technical commodities is originality, so there are no bases for comparison. This makes it difficult for the basis of the price of a commodity--exchange value--to take form during the circulation process. The State Council pointed out in its "Provisional Decisions on Technology Transfers" that "the value of a technical commodity and market regulation should be determined through negotiations by both sides." The main concern during the negotiation process often is the use of a technical commodity, and there always is a hope that adoption of a new technology will provide the user with rather substantial economic benefits. In addition, there also is a concern for how much money must be invested to adopt a new technology or manufacture a new product. The seller's main concern, however, is whether or not it will be possible to realize the use value of the technical commodity. The mental and material labor he has expended to produce the technology must be compensated and there also should be additional economic benefits. Besides a concern for these factors, the price of technical commodities also can vary greatly according to different transfer arrangements. The price of ownership rights or monopoly rights for specific periods of time over a transferred technology should be much higher than the price of use rights over a transferred technology. The price of technical commodities cannot be determined according to costs plus profits like normal commodities. Many factors must be taken into consideration, which requires that the negotiations between buyer and seller be carried out on a basis of equality and mutual benefit.

3. Forms of payment for technical commodities.

The most simple form of payment for technical commodities is a single total payment, which means that buyer and seller negotiate a total price that is to be paid in full in one or several installments after the contract is signed. This is no different from the form of payment used for normal commodities. Because the payment is made before the buyer imports the technical commodity and sells the products, it is obvious that the buyer assumes the risk for the technical commodity. With the exception of extremely simple technical transfers, this form of payment is used very little. Current forms of payment mainly involve shared responsibility for percentage deductions: within the agreed upon time frame and after the buyer uses the imported technology to

manufacture and sell his products, the net selling price of the product (or a base amount agreed upon by both sides) will be paid to the seller according to a specific proportion. This form of payment requires that both buyer and seller assume the risk and encourages the speediest achievement of the use value of the technical commodity.

4. Forecasting technology markets.

Technology markets have become an important component of China's socialist commodity markets. The question of how the technology markets of the future will develop requires us to make scientific forecasts. Technology market forecasting requires analytical research concerning consumption structures, industrial structures and technical structures in China as well as the mutual roles and mechanisms that exist among them to predict the trend they will follow in future development. Technology market forecasting must be based on a socialized evaluation system. Evaluation of technologies not only requires that we be concerned with economic results but also requires analysis and comprehensive evaluation of their affects on nature, society and all other areas.

5. Administration and legislation of technology markets.

A major effort to develop technology markets not only requires unified management and scientific management but also requires that legislative work in this area be strengthened. The law should become the main aspect of modern social life, and it should become a major means for S&T management and administration of the extension of achievements. Legal protection should be provided for S&T personnel who take up second jobs and receive compensation during their spare time. As all areas establish a multitude of S&T development centers and technical service companies, we should formulate special S&T contract laws to reinforce unified administration of technology markets throughout China.

Jiang Shihe; Beijing University

12539/8309
CSO: 4008/2075

JIANGSU'S TECHNOLOGY IMPORTS APPRAISED

Beijing KEYAN GUANLI [SCIENCE RESEARCH MANAGEMENT] in Chinese No 1, Jan 86 pp 20-21

[Article by Dai Liren [2071 4539 0086] of the Jiangsu Province Scientific and Technical Information Institute: "An Evaluation of Technology Imports in Jiangsu Province and Countermeasures"]

[Excerpt] Active importation of advanced foreign technologies in a planned manner is one route many nations of the world have used to accelerate economic development and promote scientific and technological progress. The history of economic development in the world shows us that if a country is able to integrate with its actual conditions and take action for continual importation of advanced foreign technologies, it will conserve manpower and materials, and it will transform its situation of economic backwardness and promote the development of production and economic prosperity.

Jiangsu Province was one of the first in China to be opened to the outside world, and its technology and equipment imports have multiplied over the years. According to statistics, Jiangsu Province has had about 1,300 importation projects ranging from processing and assembly, compensated trade, joint investment operations, leasing, cooperative production, foreign exchange loans, World Bank loans, governmental and civilian loans, joint Chinese-foreign management and other forms, with a foreign capital value totaling about $700 million over the past 5 years. From 1978 to 1983, the 11 cities of Nanjing, Changzhou, Zhenjiang, Wuxi, Suzhou, Xuzhou, Lianyungang, Yangzhou, Nantong, Huaiyin and Yancheng imported 356 items in the 5 industries of machinery, electronics, light industry, textiles and chemicals from 20 countries and regions, with 113 of the projects or about one-fourth to one-third of the total involving sums in excess of 1 million yuan. Japan was the largest source of imported items, accounting for about 33.8 percent of the total.

The form of importing indicates that equipment purchases accounted for the most at 76 percent of the total number of items. Purely technical imports accounted for less than 3 percent, compensated trade for 15 percent, licensed trade and leasing for 3 percent each, and joint investment operation for only 2 percent. Of the imported items, technology imports and concurrent technology imports accounted for 53 percent of total items. Of these, 12 percent have been digested or now are being digested and absorbed, while 78 percent have gone into operation, with 47 percent of them providing results and 23 percent rather good results.

Within Jiangsu Province as a whole, differentials in abilities to match up technical foundations, foreign exchange situations, raw materials, communications, energy resources and information among industries and among cities have led to rather great differences in ability to absorb imported technologies as well as differences in ability to utilize foreign capital. The southern Jiangsu region accounted for three-fourths of expenditures and two-thirds of the items. Moreover, the levels of technology imports were rather high and the pace was fast. The characteristics of the five industries surveyed are described below.

The total value of technology imports in light industry exceeded 243 million yuan or about 20 percent of total investments in the five industries. It imported 43.5 percent of total items and 50 percent of them are providing economic benefits. The imports are characterized by a large number of items, wide distribution, small investments and rapid returns. The situation in equipment updating in the Wuxi City clothing industry indicates that the differential from foreign countries was reduced by 20 to 30 years in only 2 years' time. Since beginning to import equipment and technology, the Wuxi City Light Industry Bureau has increased the value of its exports by 25 percent a year, which was 5.7 percent higher than the rate of growth in gross value of output in the bureau.

The total value of technology imports in the textile industry exceeded 368 million yuan or 30 percent of total investments. It imported 22.7 percent of total items and 51 percent are providing results. In Changzhou City, for example, 70 percent of the additional profits in the textile industry were gained through reliance on technology imports. This shows that there is major potential for imports in the textile industry, and that it is a key industry for imports.

The total value of imports in the machine industry exceeded 392 million yuan, or 33 percent of total investments for the five industries. It accounted for only 10 percent of the number of items and only 24 percent are providing economic benefits. Its characteristics are concentration of items, large investments and long schedules.

The total value of imports in the electronics industry exceeded 182 million yuan, or 15 percent of total investments in the five industries. It accounted for 20 percent of the total number of items and 43.6 percent now are producing results. Not many key technologies were imported, however, and the scale of imports was small, so it occupies fourth place among the five industries.

The total value of imports in the chemical industry exceeded 8.5 million yuan and accounted for 0.7 percent of the total number of items. There were a limited number of items, investments were small and imports are in the take-off stage.

12539/8309
CSO: 4008/2075

BRIEFS

DEVELOPING CHEMICAL INDUSTRY--A provincial chemical industry work conference concluded in Kunming on 28 June. The meeting demanded that the leading comrades in the chemical industry continue to go deep into reality to investigate and study, solve problems in production, straighten out and firm up economic responsibility systems so as to mobilize the enthusiasm of the staff and workers, and strive to fulfill the tasks for the 1st year of the Seventh 5-Year Plan. The meeting held that Yunnan has very good conditions for developing the chemical industry, and this industry should therefore be gradually developed into a major pillar of the province's economy. Through making efforts during and beyond the Seventh 5-Year Plan, we should strive to build Yunnan into a major chemical industry base. The industry should regard support for agriculture as its primary task. The meeting proposed that the chemical industry should have an appropriate growth rate. During the Seventh 5-Year Plan, the province should in general do a good job of preparatory work for capital construction and technological transformation. It should ensure key construction projects, reduce construction cycles, and improve the results of investment. The industry should base its efforts on the existing enterprises and tapping their potentials. This is the most practical and effective way of achieving a higher growth rate and better economic results. It is also necessary to presevere in reform, invigorate the enterprises, and develop lateral ties. [Excerpts] [Kunming Yunnan Provincial Service in Mandarin 2200 GMT 29 Jun 86 HK] /9738

CSO: 4008/1105

SCHEME FOR TYPHOON WAVE CALCULATION IN NORTHERN PART OF SOUTH CHINA SEA

Beijing NANHAI HAIYANG KEXUE JIKAN [NANHAI STUDIA MARINA SINICA] in Chinese
No 1, May 80 pp 135-164

[Article* by Zhang Jinghan [1728 4842 3352] and Li Shaoying [2621 1421 5391] of the South China Sea Institute of Oceanography, Chinese Academy of Sciences]

[Text] The major large waves appearing in the South China Sea are typhoon waves. Thus, in maritime engineering planning and the exploitation and use of marine resources it is necessary to consider the effects of typhoon waves.

But how does one predict the waves caused by typhoon's which change their motion so quickly? In the course of concrete work we have provisionally used the standard method[2] for calculation. Although this method has rather good predictive results under general meteorological conditions, in view of its inability to reflect the special characteristics of typhoons and that in the process of prediction human errors are fairly large, the consequence is that the predicted results are not stable. In addition, we also compared the method of the Japanese scholar, Unoki Sanae[3] (below referred to as the Unoki method) and the method of the American Bretschneider[4] (below referred to as the Bretschneider method). Despite the fact that these methods both take more factors into consideration and their process of prediction is relatively simple, still they do not embody the conditions of rapid change in the process where a typhoon makes the waves become longer. Moreover, with regard to coastal engineering where there are rather stringent demands to know the direction of approach of typhoon waves, both these methods cannot satisfactorily specify the direction of approach of the waves. Consequently, how best to predict waves on the basis of the typhoon's motion, changes in strength, and other characteristics and a more reasonable way to determine the direction of approach of the larger waves provided the basic starting point of this paper.

---

* This article made use of the valuable opinions of our colleagues Chen Junchang and Wang Wenzhi and received the encouragement and support of Professor Yu Zhouwen of the Shandong Oceanography Academy. In actual use and testing work, Li Guoan, Liu Qingguo, and Pan Jizhe participated in a large amount of calculation. To them all we express our gratitude.

I. The Building Thought and Principles for Prediction

In the northern hemisphere, the wind direction of typhoons is counterclockwise and blows inward from any one angle (see Figure 1).[5] Consequently, the typhoon waves on the left or right side of the typhoon's direction of motion have the following basic characteristics: First on the left side, since the wind direction of the typhoon's large winds is basically opposite to the typhoon's direction of motion, the direction of the large waves caused by the typhoon is also in the opposite direction to the motion of the typhoon itself. On the right side this is reversed; the direction of large winds and of the big waves is basically the same as the direction of the typhoon itself. Second, the result of the composite of the velocity vectors of the wind and the typhoon make it so the distribution of actual wind speeds and the waves which the winds cause on the left and right sides is not symmetric. Those on the left side being less than those on the right side (see Figure 2). (Footnote 1) (See related works to do with calculation methods for marine waves in regions of moving winds by the Japanese authors Toshima Shu and Ishima Takeshi and translated into Chinese by the Huadong Hydrology Academy.) Third, for a point to the left of a typhoon the instant when the largest waves occur is always later than the time of greatest winds for the same point but for a point on the right side this is not so. If the typhoon is moving rapidly, the time of occurrence of the largest waves is even later than the time of greatest winds. Conversely, if the typhoon is moving slowly, the maximum winds come just after the appearance of maximum waves. Therefore, to embody these distinctions this article will apply different typhoon prediction schemes to the two types of situations outlined above.

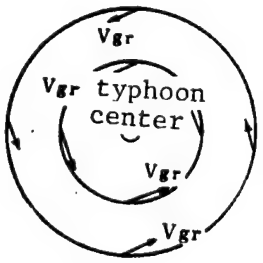


Figure 1. Gradient and Wind Direction in a Typhoon Region

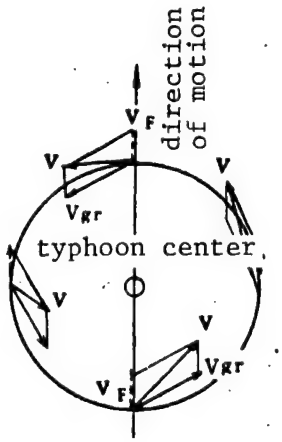
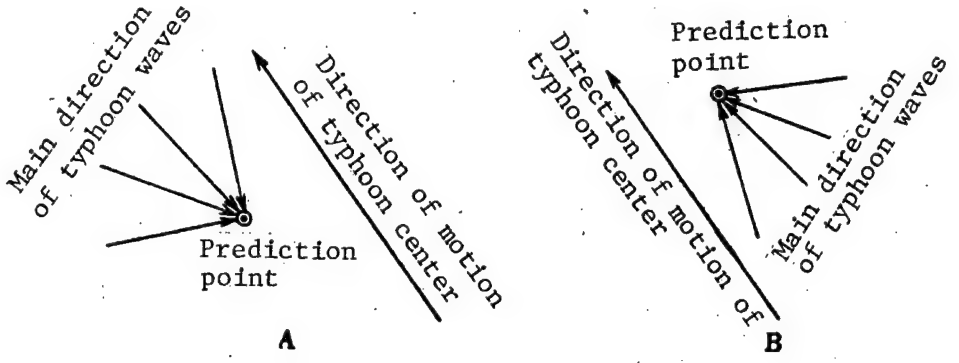


Figure 2. Wind Components in a Typhoon Region

For the situation of the first type (as in Figure 3A) because the direction of approach of the typhoon waves is basically opposite to the typhoon's direction of motion, the main directional line selected for calculation of waves should also be basically opposite to the typhoon's direction of motion.



A. Prediction point located to the left of the typhoon's direction of motion

B. Prediction point located to the right of the typhoon's direction of motion

Figure 3. Relationship Between Main Direction of Typhoon Waves and the Motion of the Typhoon

As is evident in Figure 3A, in the course of the typhoon's motion, the point on the main directional line which first receives the influence of the effective wind (with wind directions within a 30° range to the predicted main directional line) is the beginning calculation point on this line (i.e., the prediction point). Thus, in the time period the prediction point receives effective wind effects, the wind speed can be calculated for different times in the course of the typhoon's motion for various points (homogeneously selected by the predictor) on the main directional line. At the same time, to avoid discontinuities in changes of the wind speed at various points on the main directional line we also seek to use the values of the static wind speed on this line. This article will project the wind speeds at the various points onto the main directional line, use a kind of averaging process to calculate the average wind speed on the main directional line, and finally, selecting appropriate wind elements, predict the wave elements.

As for the second type situation (as in Figure 3B), aside from noting the changes in wind speed, the situation of wave evolution under conditions of piece-wise evolution of the wind area toward the prediction point also is considered. This is explained with Figure 4 as follows:

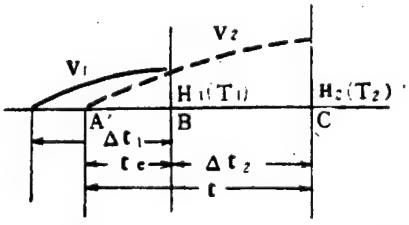


Figure 4. Method for Calculation of Waves With Changing Speed

Under the action of the average wind speed, V_1, the waves in the wind area segment beginning at point A gradually lengthen. After a time period Δt_1, the wave height of the smallest wind region along the vicinity of point B corresponding with wind time Δt_1 is H_1. Then take point B as wind area of the next segment waves calculated and continue on, in the new wind area the average wind speed is $V_2 (V_2 > V_1)$. This way the waves in the vicinity of point B continue to lengthen in the new wind region and after another time interval, Δt_2, the wave height reached at point C is H_2. By this process, the prediction point can be reached.

If we consider waves in the vicinity of point B caused by V_2 then its equivalent wind time is t_e and the wind region corresponding to V_2 and t_e is A'B. So from Figure 4 it can be seen from the wave calculated beginning at A' that after the average wind speed V_2 has blown for t hours, the wave in the vicinity of point C along the smallest wind region corresponding to the wind time t is H_2 (T_2).

Therefore, when the wind speed changes and the wind region evolves piece-wise, the evolution of waves is continuous, the equivalent wind time and equivalent wind region can be used to calculate, and piece-wise reach the prediction point.[1] (See Footnote 1)

II. Prediction of Typhoon Waves

(1) Speed Calculation

1. Calculation of gradient wind speed

Based on "Prediction of Typhoon Winds in the Northern Part of the South China Sea" (1977) by the Meteorological Group of our South China Sea Institute of Oceanography and "Methods for Calculation of Typhoon Winds Based on Surface Level Weather Charts" by the Meteorological Sciences Research Institute of the Central Meteorological Bureau, the present article adopts the following formula for calculation of gradient wind speeds:

$$V_{gr} = r\left(\sqrt{\omega^2 \sin^2\varphi + \frac{\partial P}{\partial r}\cdot\frac{1}{\rho r}} - \omega \sin\varphi\right) \tag{1}$$

Taking $\rho = 1.16\ kg/m^3$, the rate of the earth's angular rotation $\omega = 7.29 \times 10^{-5}$, r expressed in latitude distance [4885 6415], and $\partial P/\partial r$ expressed in millibars, then the gradient wind speed formula can be written as

$$V_{gr} = 8.09\, r\sin\varphi\left(-1 + \sqrt{1 + 1.32\cdot\frac{1}{r\sin^2\varphi}\cdot\frac{\partial P}{\partial r}}\right) \tag{2}$$

Here using the American Hydrometeorological Bureau's model for stationary tropical cyclonic barometric pressure fields[5]

$$\frac{P - P_0}{P_N - P_0} = e^{-\frac{r_m}{r}} \tag{3}$$

substituting in (2) and setting the maximum wind speed radius, r_m, as 0.6 latitude distance we get

$$V_{gr} = 8.09\, r \sin\varphi \left(-1 + \sqrt{1 + 1.32 \cdot \frac{1}{r\sin^2\varphi \cdot \frac{1.67\, r^2 e^{0.6/r}}{1010 - P_0}}}\right) \tag{4}$$

Where V_{gr} -- gradient wind speed (m/s)

r -- distance from prediction point to center of typhoon latitude distance

φ -- geographid latitude of prediction point (degrees)

P_0 -- barometric pressure at the typhoon's center (millibars)

If φ is taken as the average latitude of the prediction point (actually small changes in φ do not greatly influence the gradient wind speed, see Figure 5), then from r and P_0 the gradient wind speed V_{gr} can be gotten from (4).

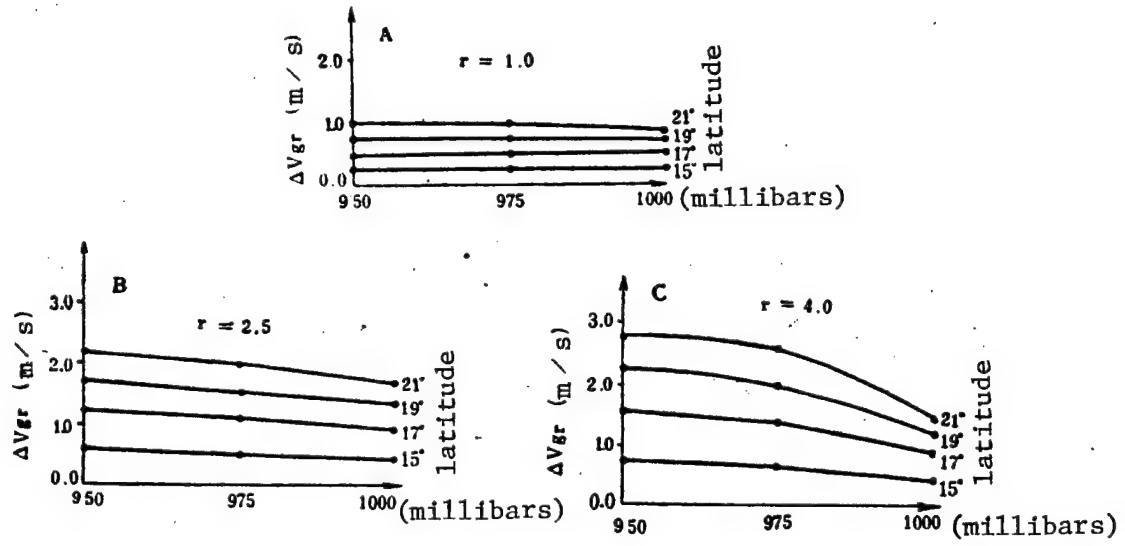


Figure 5. Relative Differences in Gradient Wind Speeds at Different Latitudes

A. Relative difference in wind speeds when r = 1.0
B. Relative difference in wind speeds when r = 2.5
C. Relative difference in wind speeds when r = 4.0

2. Calculation of marine wind speeds

Relational analysis of data on gradient wind speeds and marine winds in the northern part of the South China Sea demonstrates a clear linear correlation

between the two. (Footnote 2) (Based on 1976 data of the Meteorological Group of the South China Sea Institute of Oceanography.) Consequently, we selected observed winds and gradient winds (with wind speeds ranging from 8 to 26 m/s) shown on 56 weather charts for 9 typhoons from 1963 to 1973 and performed relational analysis, obtaining the following results

$$\text{Left side} \quad V_L = 2.00 + 0.723\ V_{gr}\ \text{m/s} \tag{5}$$

$$\text{Right side} \quad V_L = 4.10 + 0.703\ V_{gr}\ \text{m/s} \tag{6}$$

Plugging (4) into (5) and (6) we can get a look-up table for marine wind speeds to the left or right of a typhoon's motion (see Tables 1a and 1b).

(2) Calculation of waves for a prediction point to the left side of a typhoon's motion

Now with typhoon No 6608 of 26 July 1966 as example, below we describe in detail the concrete process to predict the waves in the vicinity of the wave measuring buoy at station A of Hainan Island (refer to Figure 6 and Table 2).

1. Drawing diagrams of the main direction of the typhoon's route and the main direction of the waves calculated

(i) Using a simple marine chart, plot the position and barometric pressure of the center of the typhoon for different times (e.g., 0200, 0800, 1400, 2000) and use a broken line to connect the points.

(ii) Select the main directional line for which to calculate the waves. For a rapidly moving typhoon the period of time the prediction point will experience effective wind is shorter and one selects the direction for which ΣtV^2 has the largest value as the main direction for which to calculate the waves. Conversely, for a slowly moving typhoon the prediction point experiences effective winds for a longer time period and the direction with the largest value of ΣFV^2 is the main direction. For the smaller wind areas of bays and inland seas, the main direction is also taken to be that for which ΣFV^2 is a maximum (t, F,V are wind time, wind area, and wind speed, respectively). (See Footnote 1) With regard to prediction points that are influenced by bay inlets or islands, in addition to consideration of the above elements, the factors of refraction and diffraction must be considered. These act as the fundamental criteria for selecting the main directional line. However, in actual calculation, if we just have the average wind speed, corresponding wind area, and wind time then is it not difficult to get the wave elements. Then based on the particular aspects of the typhoon waves, two or three lines basically opposite to both the direction of the typhoon's motion can be selected for doing test calculations. Finally, of these the direction of the one which works out to have the largest winds is selected as the main direction and this will be the direction of approach of the largest waves for this typhoon. According to this, in the present example the main direction is 292.5°.

Table 1a. Left Hemisphere Marine Wind Look-Up Table

($\varphi = 20°N$)

V (m/s) \ P_0 (millibars)	940	942	944	946	948	950	952	954	956	958	960	962	964	966	968	970	972	974	976	978	980	982	984	986	988	990	992	994	996	998	1000
r latitude \ distance																															
0.1																															
0.2																															
0.3	30.4	30.0	29.6	29.2	28.8	28.4	28.0	27.5	27.0	26.6	26.1	25.6	25.1	24.6	24.0	23.5	22.9	22.3	21.7	21.2	20.5	19.9	19.2	18.4	17.8	17.0	16.2	15.4	14.5	13.6	12.4
0.4	33.1	32.6	32.1	31.7	31.3	30.9	30.4	29.8	29.3	28.7	28.0	27.6	27.2	26.8	26.1	25.6	24.9	24.3	23.7	23.0	22.2	21.4	20.7	19.9	19.1	18.3	17.3	16.4	15.4	14.3	13.3
0.5	34.7	34.2	33.7	33.2	32.7	32.2	31.7	31.2	30.6	30.1	29.5	28.9	28.3	27.7	27.1	26.5	25.9	25.1	24.6	23.8	23.1	22.4	21.5	20.7	19.9	19.1	18.1	17.1	16.0	14.9	13.8
0.6	35.1	34.6	34.1	33.6	33.1	32.4	31.9	31.4	30.8	30.2	29.6	29.0	28.5	27.9	27.3	26.8	26.1	25.4	24.7	24.0	23.3	22.5	21.7	20.8	20.0	19.1	18.1	17.2	16.1	14.9	13.9
0.7	34.5	34.0	33.5	33.0	32.5	31.9	31.4	30.8	30.3	29.8	29.2	28.6	28.0	27.4	26.8	26.1	25.6	24.9	24.2	23.5	22.8	22.0	21.2	20.4	19.6	18.7	17.8	16.8	15.9	14.6	13.4
0.8	33.7	33.2	32.7	32.2	31.7	31.3	30.7	30.2	29.8	29.2	28.6	28.0	27.4	26.8	26.2	25.6	25.0	24.4	23.7	23.0	22.2	21.5	20.7	19.9	19.1	18.3	17.3	16.4	15.4	14.2	13.1
0.9	33.0	32.5	32.0	31.5	31.0	30.6	30.1	29.6	29.1	28.5	28.0	27.4	26.8	26.2	25.6	25.1	24.4	23.8	23.1	22.4	21.7	21.0	20.2	19.5	18.7	17.8	16.9	16.0	14.9	13.9	12.7
1.0	32.2	31.8	31.3	30.9	30.4	29.9	29.5	29.0	28.5	27.9	27.3	26.8	26.1	25.6	25.0	24.4	23.8	23.1	22.5	21.7	21.1	20.4	19.6	18.9	18.1	17.3	16.5	15.5	14.5	13.4	12.3
1.1	31.4	30.9	30.5	30.0	29.5	29.0	28.5	28.1	27.6	27.1	26.5	26.0	25.4	24.9	24.3	23.8	23.0	22.5	21.8	21.2	20.5	19.8	19.1	18.4	17.5	16.8	16.0	15.0	14.1	13.0	11.9
1.2	30.6	30.1	29.6	29.2	28.7	28.2	27.8	27.3	26.9	26.4	25.9	25.3	24.7	24.2	23.6	23.0	22.5	21.8	21.2	20.6	20.0	19.3	18.6	17.9	17.1	16.2	15.4	14.5	13.6	12.5	11.5
1.3	29.8	29.4	29.0	28.5	28.0	27.5	27.1	26.6	26.1	25.6	25.1	24.6	24.0	23.5	23.0	22.4	21.8	21.2	20.7	20.0	19.4	18.7	18.1	17.3	16.5	15.9	14.9	14.1	13.1	12.2	11.2
1.4	29.0	28.6	28.2	27.7	27.2	26.8	26.4	25.9	25.5	25.0	24.4	23.9	23.4	22.9	22.4	21.8	21.2	20.7	20.1	19.5	18.9	18.3	17.5	16.8	16.1	15.4	14.5	13.6	12.7	11.8	10.8
1.5	28.2	27.8	27.4	27.0	26.5	26.0	25.6	25.1	24.7	24.2	23.7	23.2	22.8	22.2	21.7	21.2	20.6	20.0	19.4	18.8	18.3	17.8	17.0	16.2	15.6	14.9	14.0	13.1	12.3	11.4	10.5
1.6	27.4	27.0	26.6	26.2	25.7	25.2	24.8	24.4	24.0	23.5	23.1	22.7	22.2	21.7	21.2	20.6	20.0	19.5	18.9	18.3	17.8	17.0	16.4	15.7	15.1	14.4	13.6	12.8	11.9	11.1	10.2
1.7	26.7	26.2	25.8	25.2	25.0	24.5	24.1	23.8	23.3	22.9	22.5	22.0	21.5	21.0	20.5	20.0	19.4	18.9	18.3	17.8	17.2	16.5	15.9	15.2	14.6	13.9	13.1	12.3	11.5	10.7	10.0
1.8	26.0	25.5	25.1	24.7	24.3	23.9	23.5	23.1	22.8	22.3	21.9	21.4	20.9	20.4	19.9	19.4	18.9	18.4	17.8	17.3	16.7	16.1	15.4	14.8	14.1	13.5	12.8	12.0	11.3	10.5	9.7
1.9	25.4	25.0	24.6	24.2	23.8	23.4	23.0	22.5	22.1	21.7	21.2	20.8	20.4	19.9	19.4	18.9	18.4	17.9	17.3	16.7	16.2	15.7	15.0	14.4	13.7	13.1	12.3	11.6	10.9	10.1	9.4
2.0	24.7	24.3	23.9	23.5	23.1	22.7	22.3	22.0	21.5	21.1	20.7	20.3	19.9	19.4	18.9	18.4	17.9	17.4	16.9	16.3	15.9	15.2	14.6	13.9	13.4	12.7	12.0	11.3	10.5	9.8	9.1
2.2	23.4	23.0	22.7	22.3	23.0	21.6	21.2	20.8	20.4	20.0	19.6	19.2	18.8	18.3	17.8	17.4	16.9	16.4	15.9	15.4	14.9	14.3	13.8	13.2	12.5	12.0	11.3	10.6	9.9	9.2	8.5
2.4	22.2	21.8	21.5	21.2	20.9	20.6	20.2	19.8	19.4	19.0	18.6	18.3	17.9	17.5	17.0	16.5	16.0	15.5	15.0	14.6	14.1	13.5	13.0	12.4	11.8	11.3	10.6	10.0	9.3	8.7	8.0
2.6	21.2	20.9	20.5	20.2	19.9	19.6	19.2	18.8	18.5	18.1	17.7	17.3	17.0	16.5	16.1	15.7	15.2	14.8	14.3	13.9	13.4	12.8	12.3	11.8	11.2	10.6	10.0	9.4	8.8	8.1	
2.8	20.3	20.0	19.7	19.4	19.0	18.6	18.3	18.0	17.6	17.2	16.8	16.5	16.2	15.9	15.2	14.8	14.4	14.0	13.6	13.1	12.7	12.2	11.7	11.1	10.6	10.1	9.4	8.8	8.2		
3.0	19.3	19.0	18.7	18.4	18.1	17.8	17.5	17.1	16.8	16.5	16.1	15.9	15.4	14.9	14.6	14.1	13.7	13.4	12.8	12.4	12.0	11.5	10.9	10.5	10.0	9.5	9.0	8.4			
3.2	18.4	18.1	17.8	17.6	17.3	17.0	16.7	16.3	16.0	15.7	15.3	15.6	14.7	14.3	13.9	13.5	13.1	12.7	12.3	11.8	11.4	11.0	10.5	10.0	9.5	9.1	8.5	8.0			
3.4	17.7	17.4	17.1	16.8	16.5	16.2	16.0	15.7	15.3	15.0	14.7	14.3	13.9	13.6	13.2	12.8	12.5	12.1	11.7	11.3	10.9	10.5	10.0	9.5	9.1	8.7	8.1				
3.6	17.0	16.7	16.4	16.1	15.8	15.6	15.2	14.9	14.6	14.3	14.0	13.6	13.3	12.9	12.5	12.2	11.8	11.5	11.1	10.7	10.3	9.9	9.5	9.1	8.6	8.1					
3.8	16.3	16.0	15.7	15.5	15.2	14.9	14.6	14.2	13.9	13.6	13.4	13.1	12.7	12.3	12.0	11.7	11.3	11.0	10.6	10.2	9.8	9.4	9.1	8.7	8.2						
4.0	15.7	15.4	15.1	14.9	14.6	14.3	14.0	13.6	13.4	13.0	12.7	12.4	12.1	11.8	11.5	11.2	10.8	10.5	10.1	9.7	9.4	9.0	8.7	8.2							
4.2	15.0	14.7	14.4	14.2	14.0	13.7	13.4	13.1	12.8	12.5	12.2	11.9	11.6	11.3	11.0	10.7	10.4	10.0	9.7	9.3	9.0	8.7	8.2	8.0							
4.4	14.4	14.1	13.8	13.6	13.4	13.1	12.8	12.5	12.3	12.0	11.7	11.4	11.1	10.8	10.5	10.2	10.0	9.6	9.3	9.0	8.7	8.3	8.0								
4.6	13.9	13.6	13.3	13.0	12.8	12.6	12.3	12.0	11.8	11.5	11.2	10.9	10.7	10.4	10.2	9.8	9.5	9.2	9.0	8.6	8.3	8.0									
4.8	13.3	13.0	12.8	12.6	12.4	12.2	11.9	11.7	11.4	11.2	10.9	10.6	10.3	10.0	9.8	9.5	9.2	9.0	8.7	8.3	8.0										
5.0	12.8	12.6	12.4	12.2	12.0	11.8	11.5	11.3	11.1	10.8	10.5	10.2	10.0	9.7	9.5	9.2	9.0	8.7	8.4	8.1											

Table 1b. Right Hemisphere Marine Wind Look-Up Table

($\varphi = 20°N$)

v (m/s) \ P_0 (millibars)	940	942	944	946	948	950	952	954	956	958	960	962	964	966	968	970	972	974	976	978	980	982	984	986	988	990	992	994	996	998	1000
r / latitude	distance																														
0.1																															
0.2																															
0.3	31.7	31.3	30.9	30.5	30.1	29.8	29.3	28.9	28.4	28.0	27.5	27.0	26.5	26.0	25.5	25.0	24.4	23.9	23.3	22.7	22.1	21.5	20.8	20.1	19.4	18.7	18.0	17.1	16.3	15.4	14.2
0.4	34.3	33.9	33.5	33.1	32.6	32.2	31.7	31.2	30.6	30.0	29.4	29.0	28.6	28.1	27.6	27.0	26.4	25.8	25.2	24.5	23.8	22.9	22.2	21.5	20.7	19.9	19.0	18.1	17.1	16.1	15.1
0.5	35.8	35.4	34.9	34.4	33.9	33.5	33.0	32.4	31.9	31.4	30.8	30.3	29.7	29.1	28.5	27.9	27.3	26.6	26.0	25.3	24.6	23.9	23.1	22.3	21.5	20.7	19.7	18.8	17.7	16.7	15.6
0.6	36.2	35.7	35.2	34.7	33.2	33.7	33.2	32.6	32.1	31.5	31.0	30.4	29.8	29.3	28.7	28.1	27.5	26.8	26.2	25.5	24.8	24.0	23.2	22.4	21.6	20.8	19.8	18.9	17.8	16.7	15.6
0.7	35.6	35.1	34.7	34.2	33.7	33.2	32.7	32.2	31.7	31.1	30.5	30.0	29.4	28.9	28.2	27.6	27.0	26.4	25.7	25.0	24.3	23.6	22.8	22.0	21.2	20.3	19.4	18.5	17.5	16.3	15.2
0.8	34.9	34.4	34.0	33.6	33.1	32.6	32.0	31.5	31.1	30.5	30.0	29.4	28.9	28.2	27.7	27.0	26.5	25.9	25.2	24.5	23.8	23.1	22.3	21.5	20.8	19.9	19.0	18.1	17.1	16.0	14.9
0.9	34.3	33.8	33.3	32.9	32.4	31.9	31.5	31.0	30.5	29.9	29.3	28.8	28.2	27.7	27.1	26.5	25.9	25.3	24.6	23.9	23.3	22.6	21.8	21.1	20.3	19.5	18.6	17.7	16.7	15.6	14.5
1.0	33.5	33.0	32.6	32.1	31.6	31.2	30.8	30.4	29.8	29.3	28.7	28.1	27.6	27.0	26.5	25.9	25.3	24.6	24.0	23.3	22.7	22.0	21.3	20.6	19.8	19.0	18.2	17.2	16.3	15.2	14.2
1.1	32.7	32.3	31.9	31.4	30.9	30.4	29.9	29.5	29.0	28.5	27.9	27.4	27.0	26.4	25.8	25.3	24.6	24.0	23.4	22.7	22.1	21.4	20.8	20.1	19.2	18.5	17.7	16.8	15.8	14.8	13.8
1.2	31.9	31.5	31.1	30.6	30.1	29.6	29.2	28.7	28.3	27.8	27.3	26.7	26.2	25.7	25.1	24.6	24.0	23.4	22.8	22.2	21.6	20.9	20.3	19.6	18.8	18.0	17.1	16.3	15.4	14.4	13.4
1.3	31.2	30.8	30.4	29.9	29.4	28.9	28.5	28.0	27.6	27.0	26.5	26.0	25.5	25.6	24.5	23.9	23.4	22.8	22.2	21.6	21.0	20.3	19.7	18.9	18.2	17.5	16.6	15.8	14.9	14.0	13.0
1.4	30.4	30.0	29.5	29.0	28.6	28.2	27.8	27.4	27.0	26.5	25.9	25.4	24.9	24.4	23.9	23.4	22.8	22.2	21.7	21.1	20.6	19.9	19.2	18.5	17.8	17.1	16.3	15.4	14.6	13.6	12.7
1.5	29.6	29.2	28.8	28.3	27.9	27.4	27.0	26.6	26.2	25.7	25.2	24.7	24.3	23.8	23.3	22.7	22.2	21.6	21.0	20.5	19.9	19.3	18.7	18.0	17.3	16.6	15.8	14.9	14.1	13.2	12.4
1.6	28.8	28.4	27.9	27.5	27.1	26.7	26.3	25.9	25.5	25.1	24.6	24.2	23.8	23.2	22.7	22.2	21.6	21.1	20.6	20.0	19.4	18.7	18.1	17.4	16.8	16.2	15.4	14.6	13.8	13.0	12.1
1.7	28.1	27.7	27.2	26.8	26.4	26.0	25.6	25.3	24.8	24.4	24.0	23.6	23.1	22.6	22.1	21.6	21.0	20.6	20.0	19.4	18.9	18.2	17.6	17.0	16.3	15.7	14.9	14.2	13.4	12.6	11.8
1.8	27.4	27.0	26.6	26.2	25.8	25.4	25.1	24.6	24.3	23.9	23.4	23.0	22.5	22.0	21.5	21.0	20.6	20.1	19.5	18.9	18.4	17.8	17.2	16.5	15.9	15.3	14.6	13.8	13.1	12.3	11.6
1.9	26.8	26.4	26.0	25.6	25.2	24.9	24.5	24.1	23.6	23.2	22.8	22.4	22.0	21.5	21.0	20.6	20.1	19.6	19.0	18.4	18.0	17.4	16.8	16.1	15.5	14.9	14.2	13.5	12.7	12.0	11.3
2.0	26.2	25.8	25.4	25.0	24.6	24.2	23.9	23.5	23.1	22.7	22.2	21.9	21.5	21.0	20.6	20.1	19.7	19.1	18.6	18.0	17.5	16.9	16.3	15.7	15.1	14.5	13.8	13.1	12.4	11.7	11.0
2.2	24.9	24.5	24.2	23.9	23.6	23.2	22.8	22.4	22.0	21.6	21.2	20.8	20.4	20.0	19.5	19.1	18.6	18.1	17.6	17.1	16.6	16.1	15.6	15.0	14.4	13.8	13.1	12.5	11.8	11.1	10.4
2.4	23.7	23.4	23.1	22.8	22.5	22.2	21.8	21.4	21.0	20.6	20.3	19.9	19.6	19.1	18.7	18.2	17.7	17.2	16.8	16.3	15.8	15.3	14.8	14.2	13.7	13.1	12.5	11.8	11.2	10.6	9.9
2.6	22.7	22.4	22.1	21.8	21.5	21.2	20.8	20.5	20.1	19.7	19.4	19.0	18.7	18.2	17.8	17.4	17.0	16.5	16.1	15.6	15.1	14.6	14.2	13.6	13.0	12.5	11.9	11.3	10.7	10.1	9.5
2.8	21.9	21.6	21.3	21.0	20.7	20.3	19.9	19.6	19.3	18.9	18.5	18.2	17.9	17.5	17.0	16.5	16.1	15.8	15.4	14.9	14.5	14.0	13.5	13.0	12.5	12.0	11.3	10.7	10.1	9.6	9.0
3.0	20.9	20.6	20.3	20.0	19.7	19.5	19.1	18.8	18.5	18.2	17.8	17.5	17.1	16.7	16.3	15.9	15.5	15.1	14.6	14.2	13.8	13.4	12.9	12.4	11.9	11.4	10.9	10.3	9.7	9.2	8.7
3.2	20.1	19.8	19.5	19.2	18.9	18.7	18.4	18.0	17.7	17.4	17.0	16.8	16.4	16.1	15.6	15.3	14.9	14.5	14.1	13.7	13.2	12.8	12.4	11.9	11.4	11.0	10.4	9.9	9.4	8.9	8.4
3.4	19.4	19.2	18.9	18.6	18.3	18.0	17.7	17.4	17.0	16.8	16.4	16.1	15.7	15.4	15.0	14.6	14.3	13.9	13.5	13.1	12.7	12.3	11.8	11.4	11.0	10.6	10.0	9.5	9.0	8.6	8.1
3.6	18.7	18.4	18.1	17.9	17.6	17.3	17.0	16.6	16.3	16.1	15.8	15.4	15.1	14.7	14.4	14.0	13.7	13.3	13.0	12.6	12.2	11.8	11.4	11.0	10.5	10.1	9.6	9.1	8.7	8.3	
3.8	18.0	17.7	17.4	17.1	16.9	16.7	16.3	16.0	15.7	15.4	15.1	14.9	14.5	14.2	13.9	13.5	13.2	12.8	12.5	12.1	11.7	11.3	11.0	10.6	10.1	9.7	9.3	8.9	8.5	8.0	
4.0	17.4	17.1	16.9	16.7	16.4	16.1	15.8	15.4	15.1	14.8	14.5	14.2	13.9	13.7	13.3	13.0	12.7	12.3	12.0	11.6	11.3	10.9	10.6	10.1	9.7	9.3	8.9	8.6	8.2		
4.2	16.8	16.5	16.3	16.1	15.8	15.5	15.2	14.9	14.6	14.3	14.0	13.8	13.5	13.2	12.8	12.5	12.3	11.9	11.6	11.2	10.9	10.6	10.1	9.8	9.4	9.0	8.7	8.3			
4.4	16.2	15.9	15.7	15.5	15.2	14.9	14.6	14.4	14.1	13.8	13.5	13.2	13.1	12.7	12.4	12.1	11.8	11.5	11.2	10.9	10.6	10.2	9.9	9.4	9.2	8.8	8.4	8.1			
4.6	15.6	15.4	15.2	14.9	14.6	14.4	14.2	13.9	13.6	13.3	13.0	12.7	12.5	12.3	12.0	11.7	11.4	11.1	10.9	10.5	10.2	9.9	9.5	9.2	8.9	8.6	8.2				
4.8	15.1	14.9	14.6	14.4	14.2	14.0	13.8	13.5	13.2	13.0	12.7	12.5	12.2	11.9	11.7	11.4	11.1	10.9	10.6	10.2	9.9	9.6	9.2	9.0	8.7	8.3	8.0				
5.0	14.6	14.3	14.1	13.9	13.7	13.6	13.4	13.2	12.9	12.7	12.4	12.1	11.9	11.6	11.4	11.1	10.9	10.6	10.3	10.0	9.7	9.4	9.0	8.8	8.5	8.1					

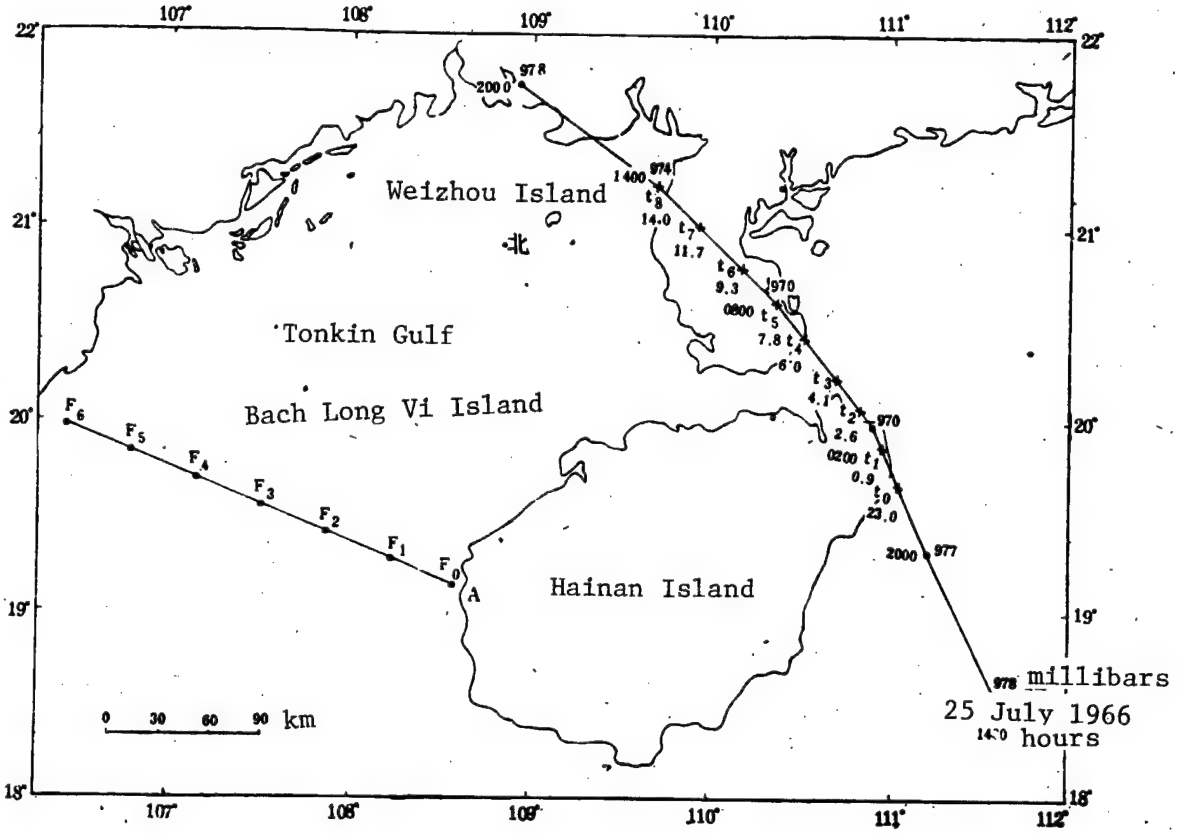


Figure 6. Wave Prediction Chart for Station A on Hainan Island on 26 July 1966

(iii) Beginning from prediction point F_0, select several, equally spaced, calculation points, F_0, F_1, ... F_n on the main directional line. For this the distance between successive points should be neither too large nor too small. If they are too far apart it will influence the precision of the calculated results and if too close together, it will increase the quantity of work. So, according to the size of the wind area, a separation between 20 and 50 km is good (this example used 44 km).

2. The construction of a convenient special rule

(i) Taking the in-deflection angle of the marine wind direction and the tangent to the ideal isobar in the typhoon wind region to be 25°, construct a preliminary special rule. The steps for doing this are: On a common hemisphere, according to latitude distance on the simple marine chart, make concentric circles every 0.1 or 0.2 latitude distance and label the latitude distance coordinate from the circles' center as r (see Figure 7). Then, at positions of 35°, 65°, and 95° draw from the center three straight lines (like lines OA, OO, and OB in Figure 7). Finally, with line OO as the zero degree line draw lines every 5° or 10° on either side of it with respect to the center and label this angle coordinate as α (the acute angle between the marine wind direction and the main directional line). This becomes the special rule shown in Figure 7.

Table 2. Prediction of Waves at Hainan Island Station A at 1400 on 26 July 1966

From Figure 6					Looked-up from Table 1a based on columns 3 and 4	From Fig 6	Calculated from column 7	④×⑧
① F_n	② t_m	③ t (hrs)	④ P_0 (millibars)	⑤ r latitude distance	⑥ V' (m/s)	⑦ α (°)	⑧ cos α	⑨ V (m/s)
F_0	t_0	23.0	973.5	2.53	15.2	30	0.866	13.2
	t_1	0.9	971.5	2.50	15.8	24	0.914	14.4
	t_2	2.6	970.0	2.45	16.3	19	0.946	15.4
	t_3	4.1	970.0	2.40	16.5	13	0.974	16.1
	t_4	6.0	970.0	2.37	16.6	8	0.991	16.5
	t_5	7.8	970.0	2.35	16.7	1	0.999	16.7
	t_6	9.3	971.0	2.35	16.5	4	0.998	16.5
	t_7	11.7	972.5	2.37	16.0	13	0.974	15.6
	t_8	14.0	974.0	2.47	15.3	21	0.934	14.3
F_1		as above		2.84	14.0	34	0.829	11.6
				2.78	14.6	30	0.866	12.6
				2.73	15.1	25	0.906	13.7
				2.65	15.4	20	0.940	14.5
				2.58	15.8	15	0.966	15.3
				2.55	15.9	10	0.985	15.7
				2.50	15.9	6	0.995	15.8
				2.50	15.5	4	0.998	15.5
(F_0—$F_1$44 km)				2.51	15.1	12	0.978	14.8
F_2		as above		3.20	12.8	38	0.788	10.1
				3.14	13.4	34	0.829	11.1
				3.05	14.0	30	0.866	12.1
				2.95	14.4	25	0.906	13.0
				2.86	14.7	20	0.940	13.8
				2.78	14.9	16	0.961	14.3
				2.72	14.9	11	0.982	14.6
				2.65	14.9	4	0.998	14.8
(F_0—$F_2$88 km)				2.64	14.6	4	0.998	14.5
F_3		as above		3.55	11.8	41	0.755	8.9
				3.47	12.4	37	0.799	9.9
				3.37	12.9	33	0.839	10.8
				3.27	13.3	30	0.866	11.5
				3.16	13.6	25	0.906	12.3
				3.08	13.9	21	0.934	13.0
				2.98	14.0	17	0.956	13.4
				2.87	14.1	10	0.985	13.9
(F_0—$F_3$132 km)				2.80	14.0	4	0.998	13.9
F_4		as above		3.88	11.0	42	0.743	8.2
				3.80	11.5	38	0.788	9.1
				3.70	12.0	36	0.809	9.7
				3.60	12.2	33	0.836	10.2
				3.47	12.6	30	0.866	10.9
				3.37	12.9	26	0.899	11.6
				3.25	13.1	22	0.927	12.1
				3.13	13.2	16	0.961	12.7
(F_0—$F_4$176 km)				3.03	13.2	10	0.985	13.0
F_5		as above		4.25	10.0	45	0.707	7.1
				4.15	10.6	42	0.743	7.9
				4.05	11.1	39	0.777	8.6
				3.92	11.4	36	0.809	9.2
				3.78	11.8	33	0.839	9.9
				3.67	12.0	30	0.866	10.4
				3.55	12.2	26	0.899	11.0
				3.38	12.5	21	0.934	11.7
(F_0—$F_5$220 km)				3.26	12.5	16	0.961	12.0
F_6		as above		4.62	9.3	47	0.682	6.3
				4.50	9.9	44	0.719	7.1
				4.38	10.3	41	0.755	7.8
				4.25	10.6	39	0.777	8.2
				4.10	11.0	36	0.809	8.9
				3.98	11.3	33	0.839	9.5
				3.82	11.5	30	0.866	10.0
				3.66	11.6	25	0.906	10.5
(F_0—$F_6$264 km)				3.53	11.8	20	0.940	11.1

Calculated based on formula (7)								From 2 based on 10	Looked-up in 2,3	Looked-up based on 1 10,12	Calculated based on 10, 12,13	Looked-up Fig.9-7 based on 12,13,14	
⑩$_1$ $\bar{V}_{t_{m-}t_{m+1}}$	⑩$_2$ $\bar{V}_{t_{m-}t_{m+2}}$	⑩$_3$ $\bar{V}_{t_{m-}t_{m+3}}$	⑩$_4$ $\bar{V}_{t_{m-}t_{m+4}}$	⑩$_5$ $\bar{V}_{t_{m-}t_{m+5}}$	⑩$_6$ $\bar{V}_{t_{m-}t_{m+6}}$	⑩$_7$ $\bar{V}_{t_{m-}t_{m+7}}$	⑩$_8$ $\bar{V}_{t_{m-}t_{m+8}}$	⑪ t_{range}	⑫ t (hrs)	⑬ F(km)	⑭ $\bar{V}$(m/s)	⑮ $H_{\frac{1}{10}}$(m)	⑯ $\bar{T}$(sec)
14.0								t_2-t_8	11.4	176	14.2	3.40	6.6
15.1	14.9												
15.9	15.7	15.5					•	t_2-t_8	11.4	220	13.6	3.40	6.6
16.4	16.2	16.0	15.8										
16.6	16.5	16.4	16.3	16.1				t_3-t_8	9.9	176	14.2	3.40	6.6
16.5	16.5	16.5	16.5	16.4	16.3								
15.8	16.0	16.1	16.2	16.3	16.3	16.3		t_3-t_8	9.9	220	13.7	3.33	6.5
14.6	14.9	15.1	15.3	**15.5**	15.7	15.8	15.9	t_0-t_2	3.6	44	14.0	2.10	5.1
12.3								t_0-t_3	5.1	88	13.8	2.65	5.8
13.4	13.1												
14.3	14.0	13.7						$t_0-t_3-t_8$	4.5+9.9 =14.4	176	14.2	3.40	6.6
15.1	14.9	14.6	14.3										
15.6	15.4	15.2	15.0	14.8					5.2+9.9 =15.1	220	13.7	3.45	6.7
15.8	15.7	15.6	15.5	15.3	15.1						shallow		
15.6	15.6	15.6	15.6	15.6	15.5	15.4					water coefficient	0.914	
14.9	15.0	15.1	15.2	**15.3**	15.4	15.4	15.4				refraction coefficient	0.913	
10.8											Observation point crossing height	2.85	(m)
11.8	11.5												
12.7	12.4	12.1											
13.6	13.3	13.0	12.7										
14.1	13.9	13.7	13.5	13.3									
14.5	14.4	14.2	14.0	13.8	13.6								
14.7	14.6	14.5	14.4	14.3	14.1	13.9							
14.6	14.6	14.6	14.6	**14.5**	14.4	14.3	14.2						
9.6													
10.5	10.2												
11.3	11.1	10.9											
12.1	11.9	11.7	11.5										
12.8	12.6	12.4	12.2	12.0									
13.3	13.1	12.9	12.7	12.5	12.3								
13.7	13.6	13.4	13.2	13.0	12.8	12.6							
13.9	13.8	13.7	13.6	**13.5**	13.3	13.1	12.9						
8.8													
9.5	9.3												
10.0	9.8	9.6											
10.7	10.5	10.3	10.1										
11.4	11.2	11.0	10.8	10.6									
11.9	11.7	11.5	11.3	11.1	10.9								
12.5	12.3	12.1	11.9	11.7	11.5	11.3							
12.9	12.8	12.6	12.4	**12.2**	12.0	11.8	11.6						
7.7													
8.4	8.2												
9.0	8.8	8.6											
9.7	9.5	9.3	9.1										
10.2	10.0	9.8	9.6	9.4									
10.8	10.6	10.4	10.2	10.0	9.8								
11.5	11.3	11.1	10.9	10.7	10.5	10.3							
11.9	11.8	11.6	11.4	11.2	11.0	10.8	10.6						
6.9													
7.6	7.4												
8.0	7.8	7.7											
8.7	8.5	8.3	8.1										
9.3	9.1	8.9	8.7	8.5									
9.8	9.6	9.4	9.2	9.0	8.8								
10.3	10.1	9.9	9.7	9.5	9.3	9.1							
10.9	10.7	10.5	10.3	10.1	9.9	9.7	9.5						

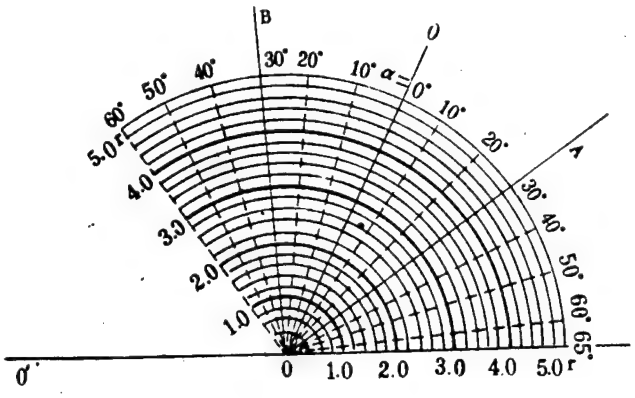


Figure 7. Simple Special Rule

(ii) Using the special rule pick off the respective times t_0, t_1, ...t_m when each point F_0, F_1, ...F_n begins to receive the influence of the effective winds and the time when the calculation point F_0 becomes free of the influence of the effective winds.

Now with point F_0 in Figure 6 as example, the process of picking off the points is explained. Using a special rule constructed on organic glass or tracing paper, line up the point 0 and the line 00' on the rule with the point F_0 and the main directional line in Figure 6 (as in Figure 8). Then the intersection points of the lines OA and OB on the special rule and the line of motion of the typhoon center in Figure 6 (the path indicated by the arrows in the figure), like points t_0 and t_{10} in Figure 8, are the times when point F_0 began and ceased to experience the effective winds. That is to say, when the typhoon moved to a position corresponding to t_0, the point F_0 began to receive the influence of the effective winds and when the typhoon center got to the position for t_{10}, the point F_0 came out from under the influence of the effective winds.

Similarly, using the special rule with its point 0 coincident with F_1, F_2, ...F_n of Figure 6 and line 00' on top of the main directional line, the times t_1, t_2, ...t_m when the points F_1, F_2, ...F_n begin to experience the effective wind can be marked off.

(iii) Using the special rule one then reads off the acute angle α (in degrees) between the marine winds and the main directional line for each point F_0, F_1, ...F_n at the times t_0, t_1, ...t_m. At the same time the distances r (latitude distance) from the position of the typhoon center at the times t_0, t_1, ...t_m to the points F_0, F_1, ...F_n can also be read off.

Similarly, this is explained below with point F_0 as example. When the point 0 and the 0'0 on the special ruler are made to coincide with point F_0 in Figure 6 and with the main directional line, the angle α and the latitude distance r on the special rule for points t_0, t_1, ...t_m are read off as 30°, 3.70r, 25°, 3.60r, ...30°, 3.52r. Of these, the first data pair is

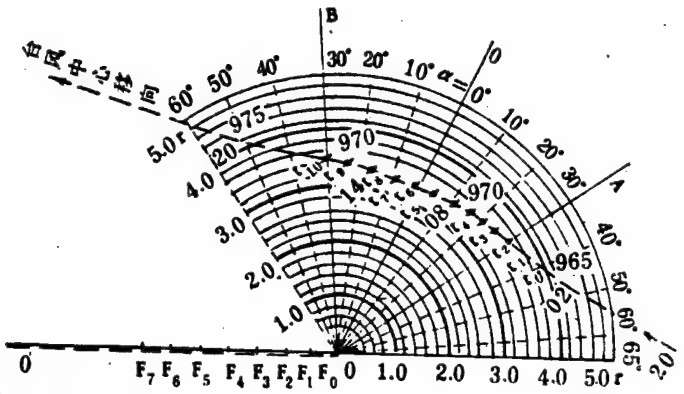


Figure 8. Example of the Use of the Simple Special Rule

the position time of the typhoon center at the instant t_0. The acute angle between the typhoon wind direction at position F_0 and the main position line is 30° and at that time the distance from the typhoon center to point F_0 is 3.70 latitude distance.

By the same steps, angle α and the latitude distance value r_0 for each point F_1, F_2, ...F_n can be arrived at.

3. Calculating the wind and the wave elements

For the calculation of the wind and wave elements see Table 2. Here we provide a supplementary explanation.

(i) Calculation of average wind speed. The average wind speed in each time segment for points F_0, F_1, ...F_n is calculated in column 10 of Table 2. The formula for this calculation is the empirical formula for falling and rising of wind speeds over time used by the National Oceanography Bureau's "Marine Wave Calculation Handbook," (1973).

$$\begin{aligned} \text{rising } V_R &= 0.3\ V_1 + 0.7\ V_2 \\ \text{rising } V_R &= 0.2\ V_1 + 0.8\ V_2 \end{aligned} \qquad (7)$$

where V_1 and V_2, respectively, represent the wind speed value before and after the instant in question. (Footnote 3) (See 1973 data of the National Oceanography Bureau.)

Now we explain the calculation steps with point F_0 as example. First, based on the wind speed value at each instant at point F_0 (column 9 of Table 2) test calculate the average wind speed $\overline{V}_{t_m - t_{m+1}}$ in each time range $t_0 - t_1$, $t_1 - t_2$, ...$t_{m-1} - t_m$ according to formula (7) (i.e., 14.0, 15.1, ...14.6 m/s in column 10_1). Then with these as the wind speed for before

and after the instant in question use formula (7) again to get average wind speed between the two time intervals $\overline{V}_{t_m-t_{m+2}}$ (i.e., 14.9, 15.7, ·····14.9 m/s in column 10) continuing in the same way until the average wind speed $\overline{V}_{t_m-t_{m+2}}$ in the range t_m-t_{m+8} is obtained (i.e., 15.9 m/s in column 10).

By these same principles, the average wind speed within each time interval at each point F_1, F_2, ...F_n can be calculated.

If the average wind speed for a particular time segment in a particular length of wind region is desired, then one can take the wind speed values within the range of the same time interval for calculation points which are contained in the wind area and work out an arithmetic average. For example, the average wind speed in the table at the points F_0, F_1, ·····F_4 during the time segment t_3-t_8 are respectively 15.5, 15.3, 14.5, 13.5, and 12.2 m/s, and the arithmetic mean of these wind speed values is 14.2 m/s. This is the average wind speed value which corresponds to the wind region length F_0-F_4 (176 km) and wind time t_3-t_8 (9.9 hours).

The calculation of other average wind speeds is done similarly.

(ii) Calculation of wave elements. From the above multicomponent wind elements, the multicomponent wave elements can be looked up via Figure 9 (Footnote 4) (If using a computer for these calculations, please refer to the relevant formulas in "Marine Wave Teaching Materials" for 1976 by the Shandong Oceanography Academy.) and large wind and wave elements are written in columns 11-16 of Table 2, taking into consideration calculation of effective wind times. If the beginning time in the calculation of elements of larger waves is t_0, then the result of calculation is the required value. If adopting a beginning time at a particular instant after t_0, (like t_3 in this example), then you will do calculation using the effective wind times. (Footnote 5) (See 1973 material from the National Oceanographic Bureau.)

From columns 11-16 in Table 2 we see that the time range for calculating larger waves is t_3-t_8 (i.e., 9.9 hours wind time) and there are two sets of numbers to wind area and wind speed, 176 km 14.2 m/s and 220 km 13.7 m/s. Before calculation of effective wind time has been applied they give, respectively, wave heights of 3.4 m and 3.33 m. Neither of these two waves are final predicted values because the calculation point in the time interval t_0-t_3 has already felt the action of effective winds and at instant t_3 a wave height of 2.65 m appears. Because of this, we must consider the wind times required to produce 2.65 m wave heights under the action of the above wind speeds (4.5 and 5.2 hours are the effective wind times). These sort of wind times and the 9.9 hours which produced the larger waves recounted above are added together giving the new wind times of 14.4 and 15.1, consequently we get, respectively, 3.4 m and 3.45 m wave heights. Obviously, here since we used the results of effective wind time calculation the final predicted value ought to be 3.45 m. After correction for shallow water and refraction, this is the predicted value of the wave height at the observation point.

It is evident from this that adoption of multiple wind elements and doing the calculation with effective wind times can enhance the larger effect of wind

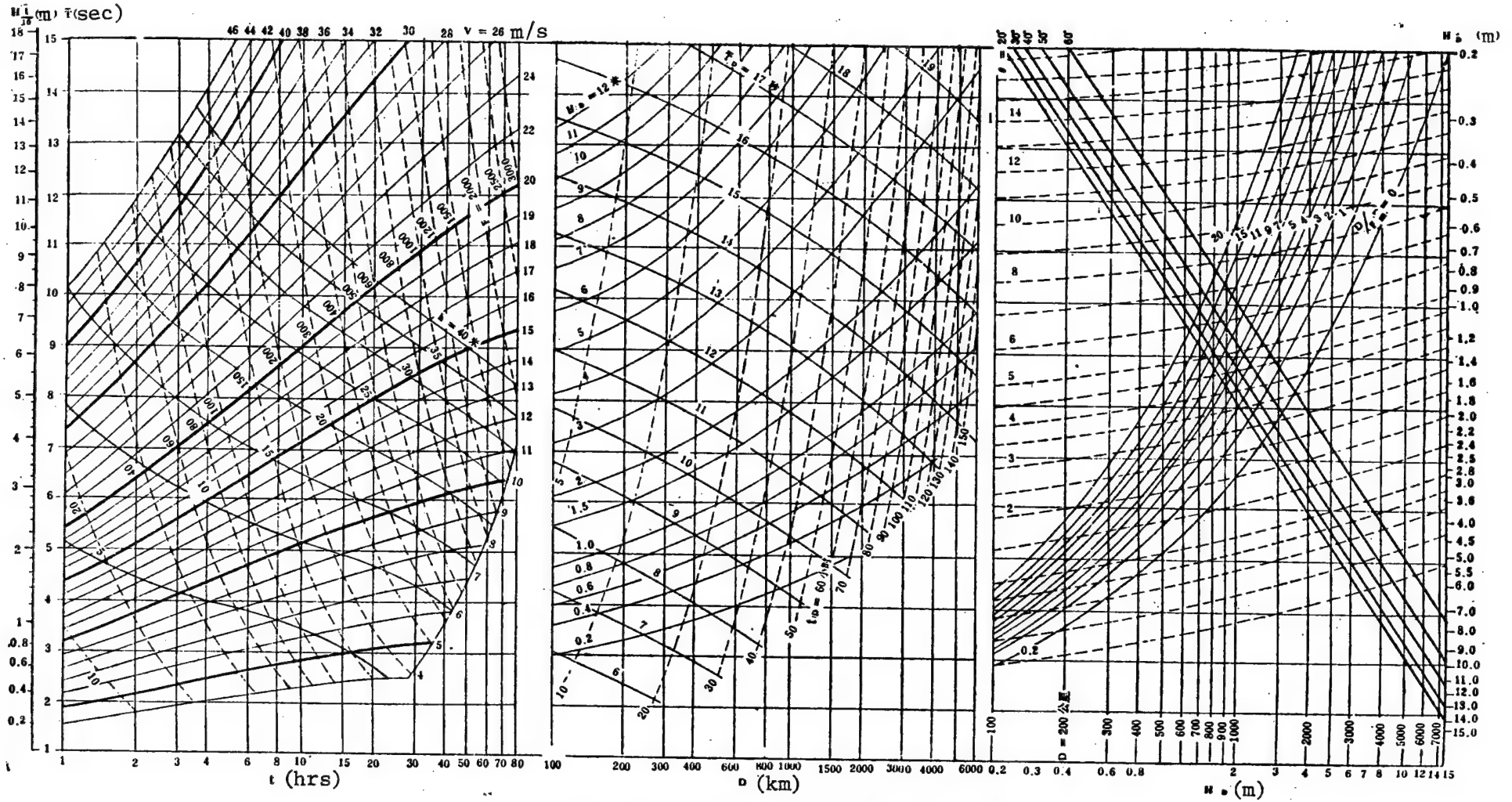


Figure 9.1 Graphs for Calculating Wave Elements

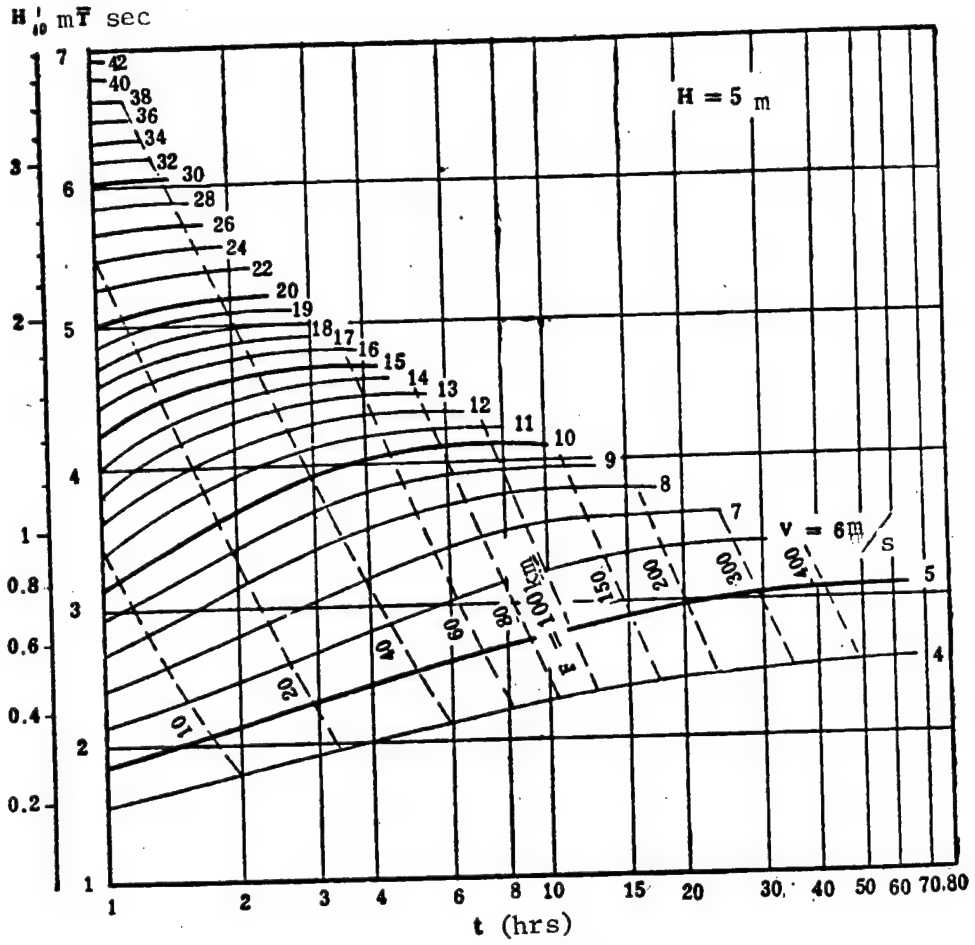


Figure 9.2 Graph for Calculating Shallow Water Wind Waves (Water depth 5 m)

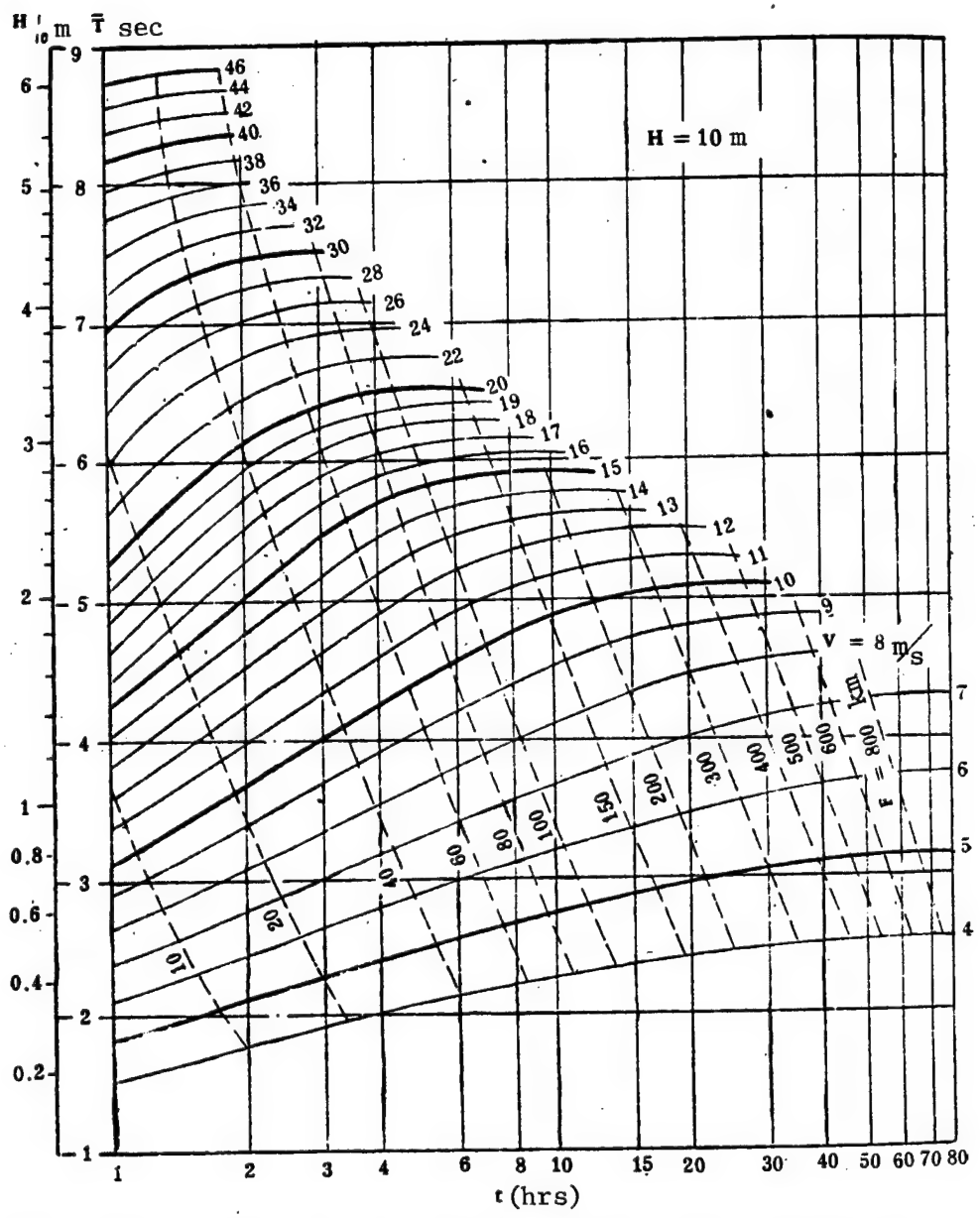


Figure 9-3. Graph for Calculating Shallow Water Wind Waves (Water depth 10 m)

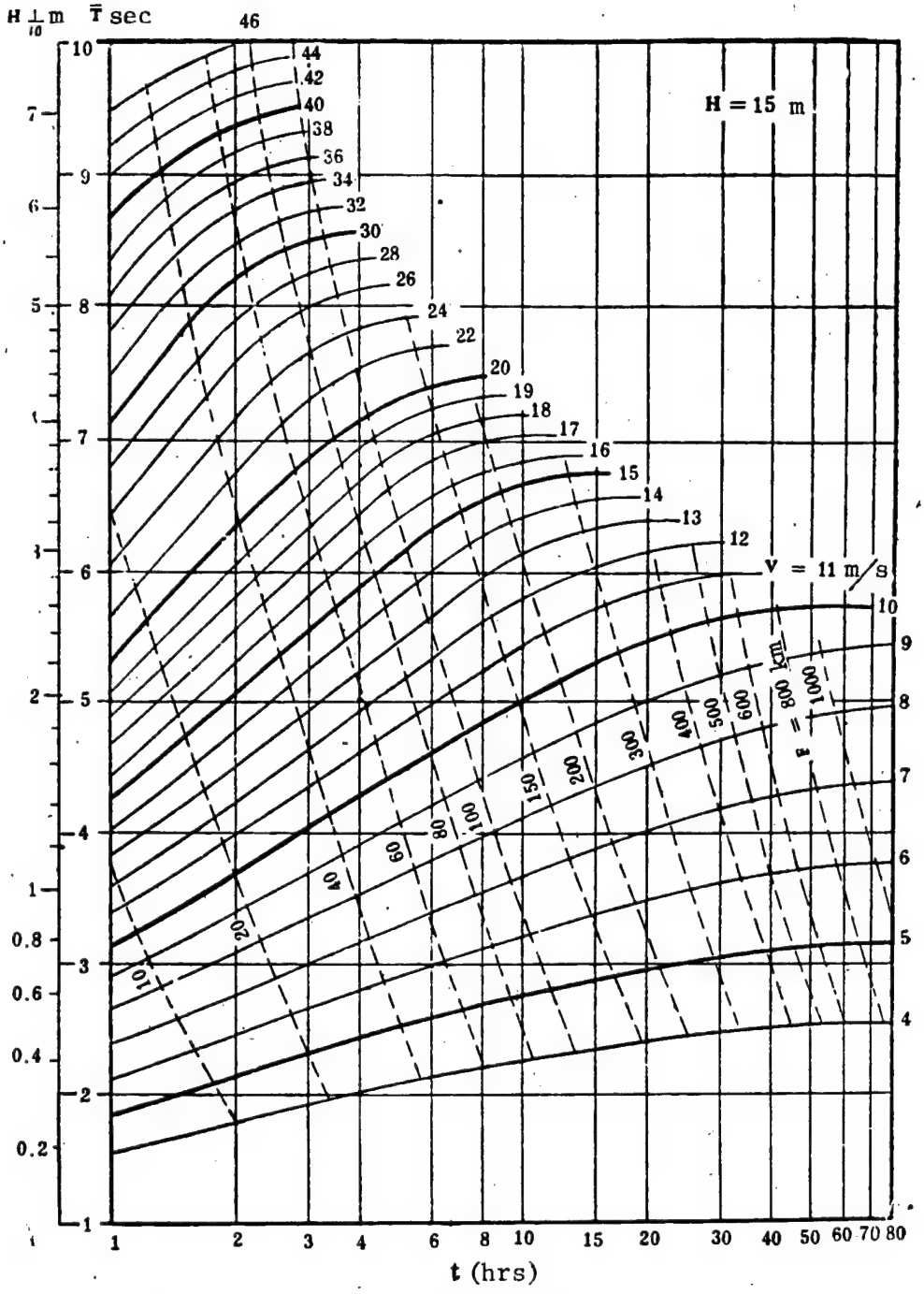


Figure 9-4. Graph for Calculating Shallow Water Wind Waves (Water depth 15 m)

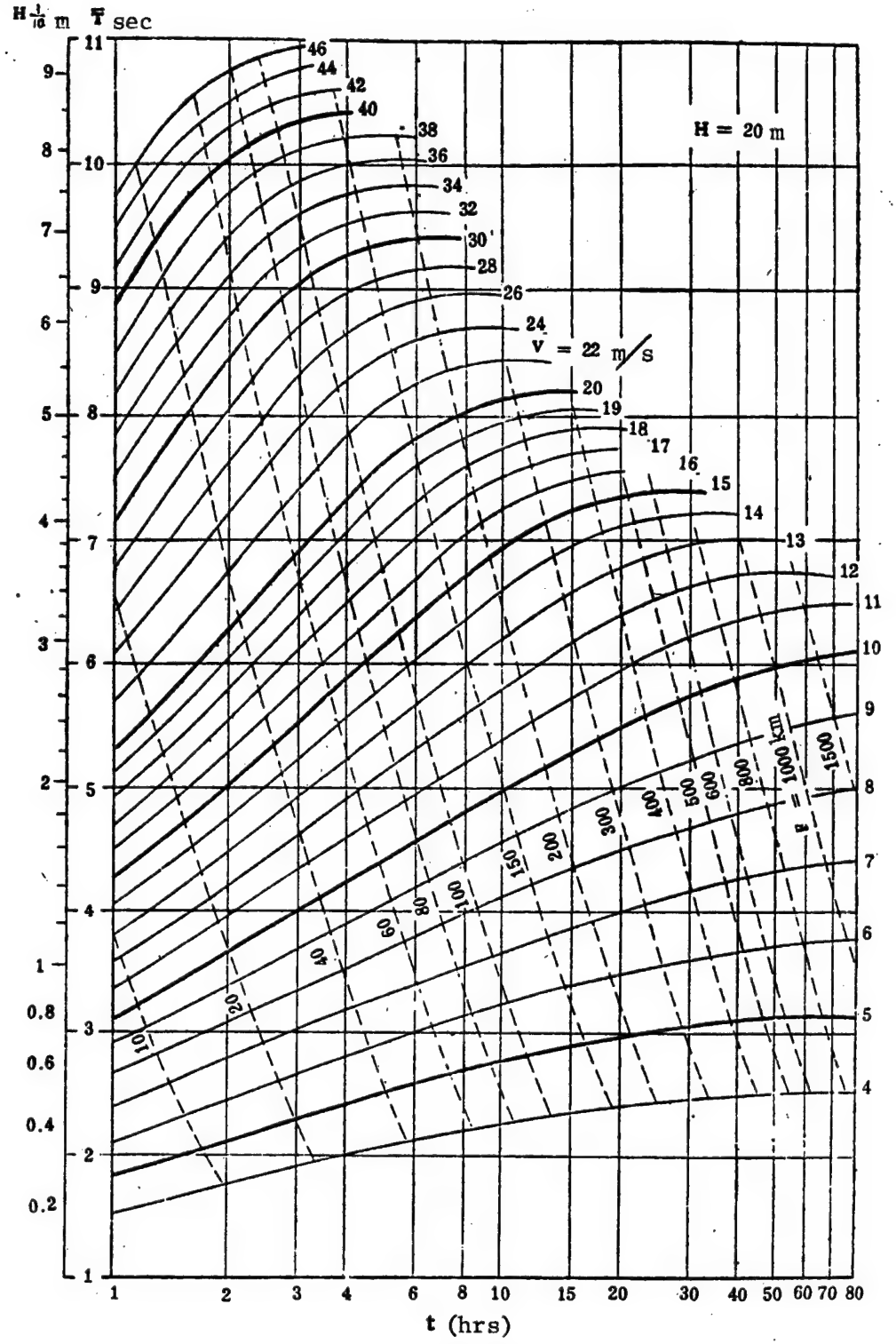


Figure 9-5. Graph for Calculating Shallow Water Wind Waves (Water depth 20 m)

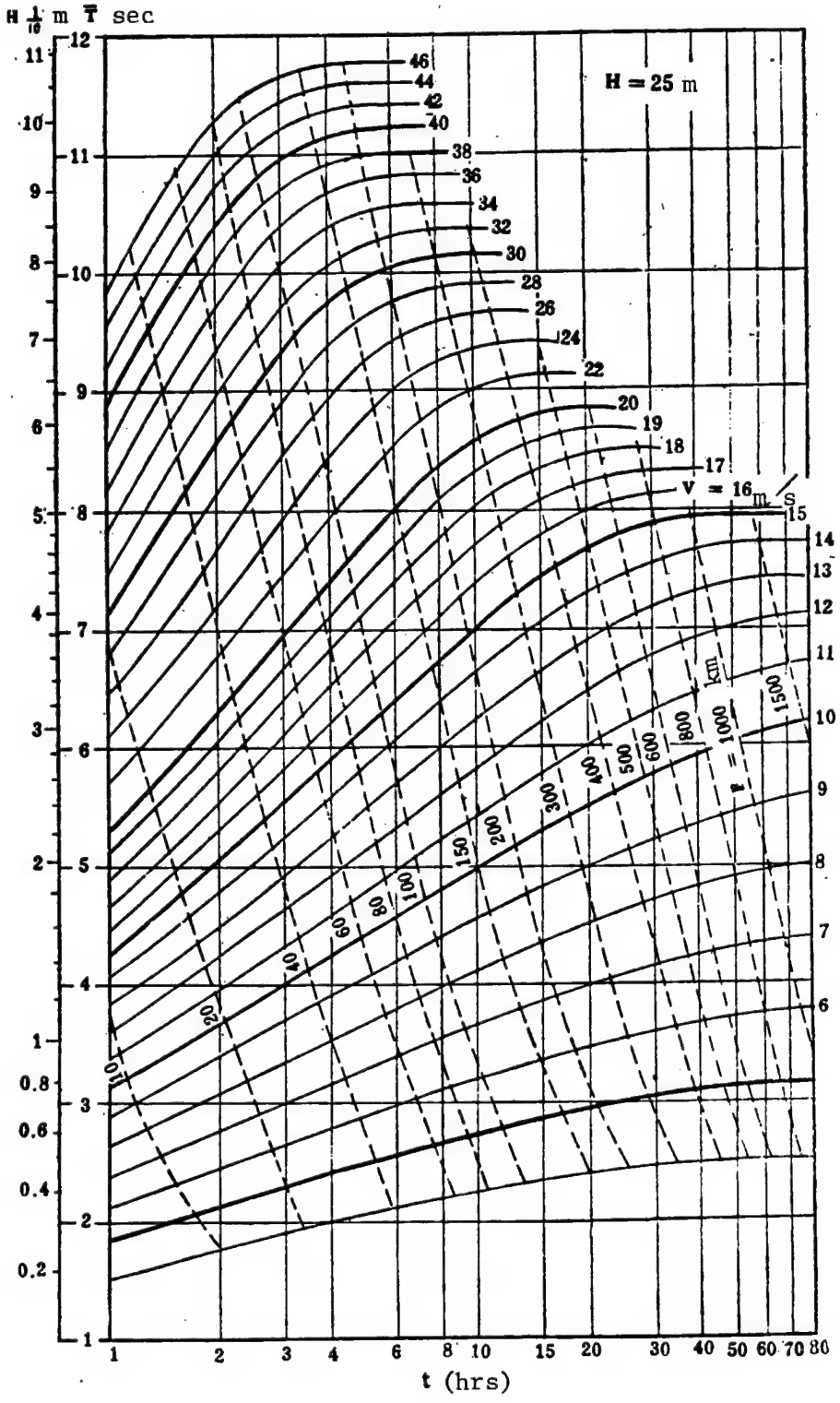


Figure 9-6. Graph for Calculating Shallow Water Wind Waves (Water depth 25m)

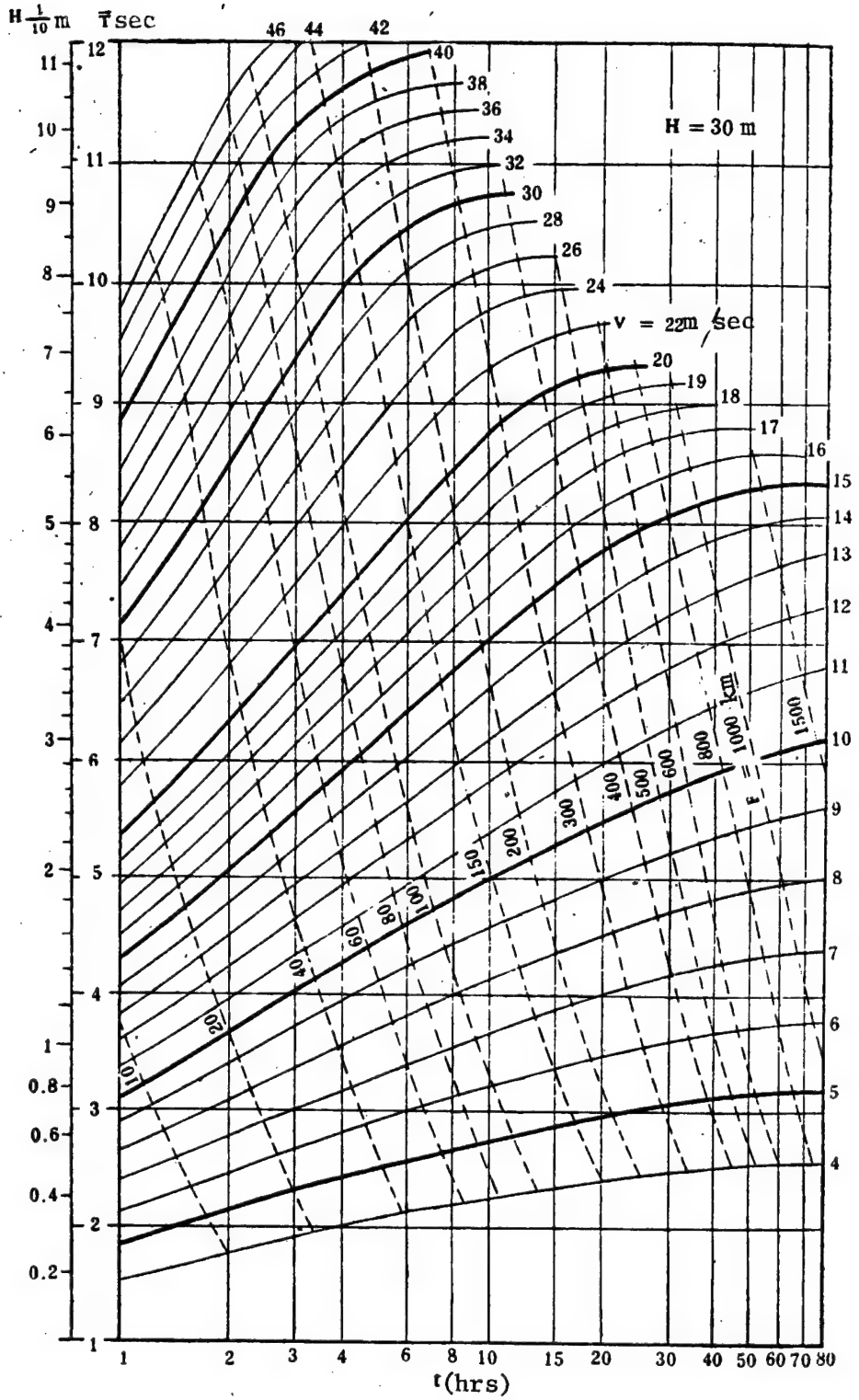


Figure 9-7. Graph for Calculating Shallow Water Wind Waves (Water depth 30 m)

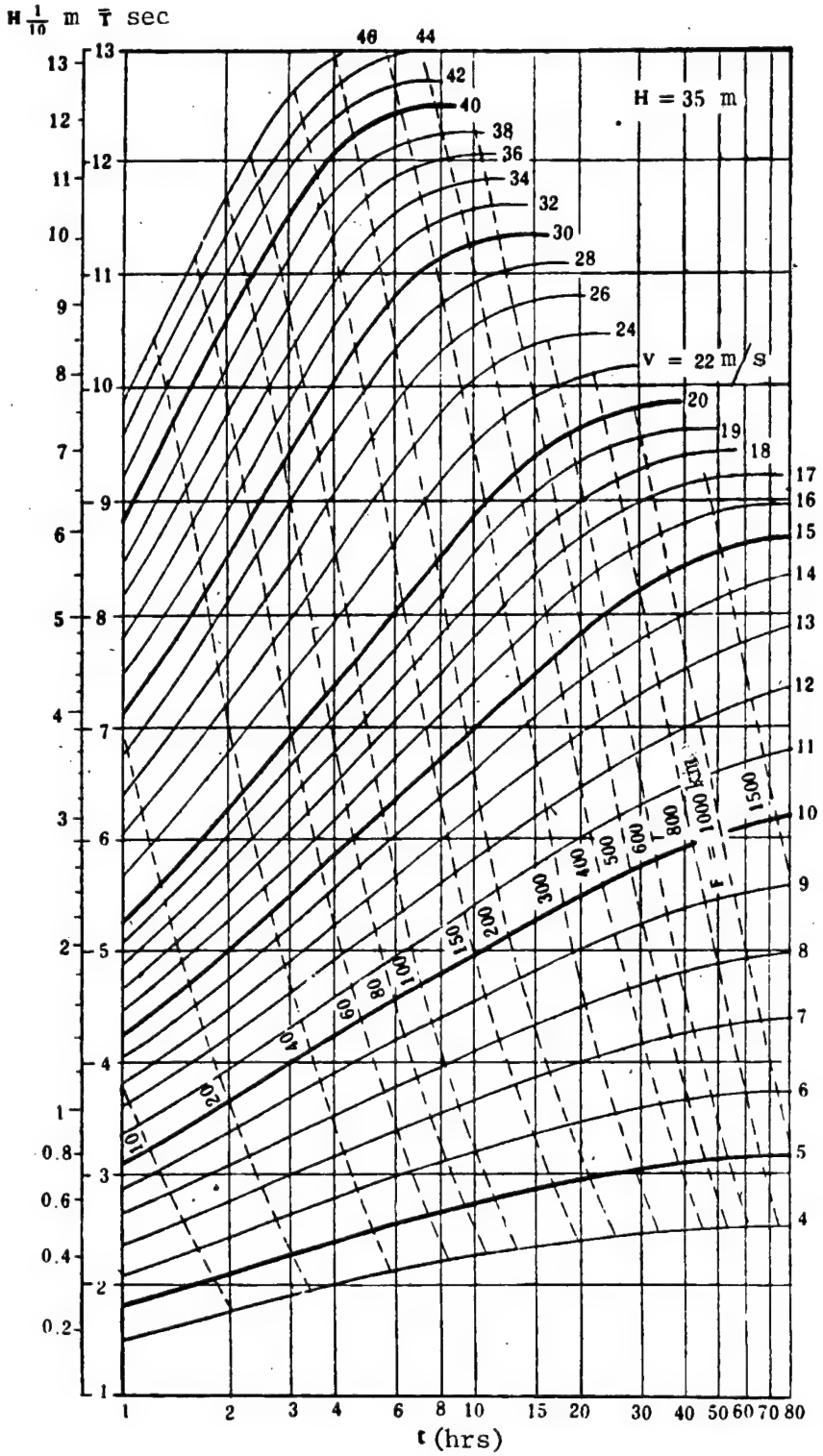


Figure 9-8. Graph for Calculating Shallow Water Wind Waves (Water depth 35 m)

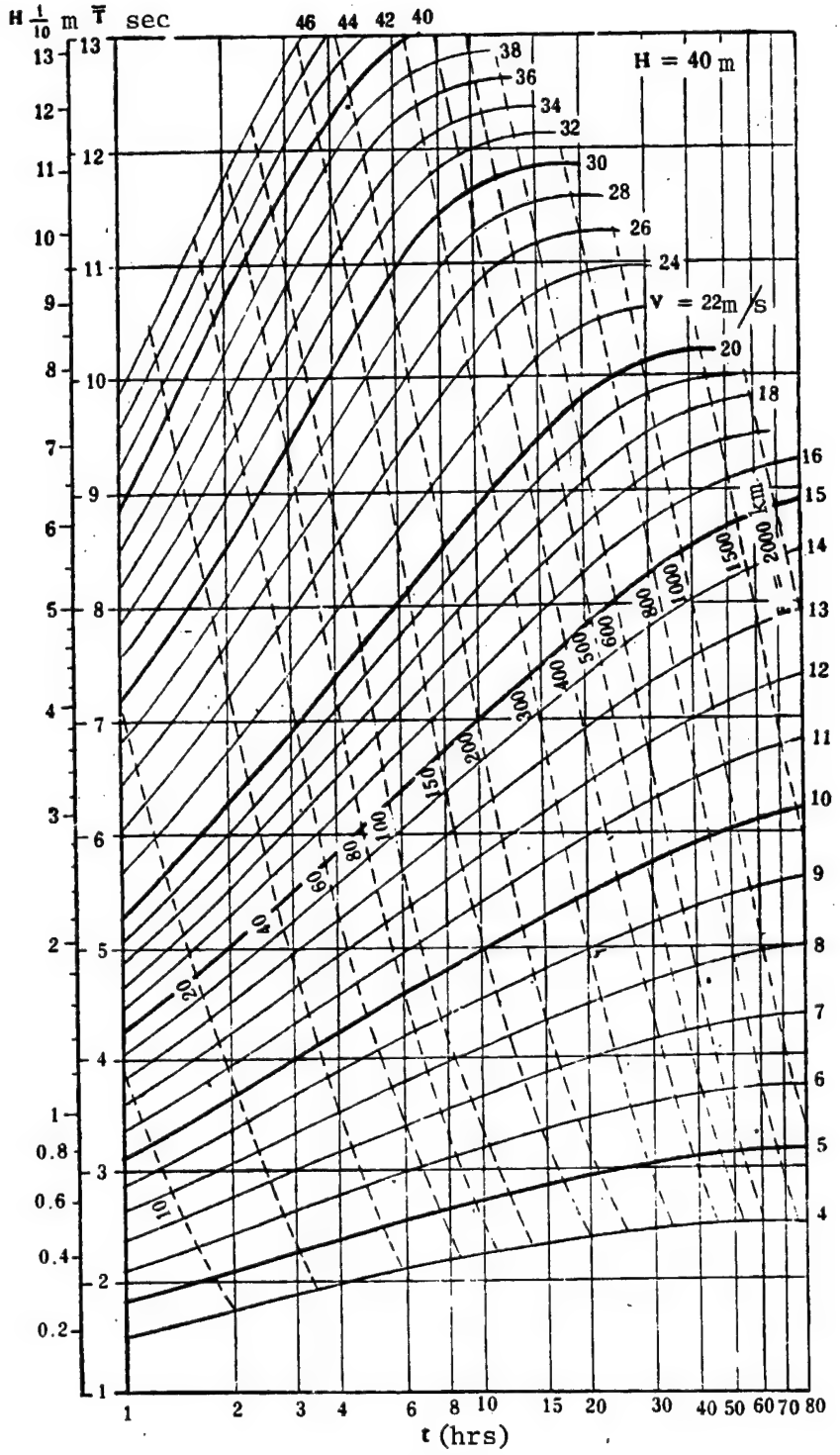


Figure 9-9. Graph for Calculating Shallow Water Wind Waves (Water depth 40 m)

time, wind area, and wind speed in finding wave elements and also gives more appropriate wave elements.

According to the steps outlined above, we predicted $H\frac{1}{10}$ wave heights of 2.85 m and 6.7 sec in the vicinity of the wave measuring buoy at station A (with an average depth of 10 m) on that day at 1400.

III. Wave Prediction With the Prediction Station Located on the Right Side of the Typhoon's Direction of Motion

With typhoon No 7703 on 21 July 1977 as example, prediction of typhoon waves at the Tonkin Gulf Station C is explained. The concrete steps follow (see Figure 10 and Table 3).

1. Drawing a diagram of the typhoon course and main direction of predicted waves

(i) Using a simple marine chart, mark the position of the typhoon center and the value of barometric pressure at the center at different times connecting the points with a broken line.

(ii) Select the main directional line for the calculation of waves. Because the method used here is to predict the waves piece-wise based on the motion of the typhoon, we can directly select two or three main directional lines to calculate the waves finally, determining the elements of the largest waves at the prediction point. In actual calculation based on the course of the typhoon and the speed of its motion main directional lines fundamentally the same as the typhoon's direction can be selected (like the main directions of 106°, 115°, and 125° in Figure 10) for separate calculation. Finally, the best main directional line can be determined. (For this example, it was the 115° line.)

(iii) Beginning from the prediction point, some calculation points 0, F_{n-1}, ...F_0 are equally spaced on the main directional line. Depending on the size of the marine area, the spacing (ΔF) can be 30-60 km. (Here we picked 33 km.)

(iv) With a suitable time interval (Δt) fix time points t_0, t_1, ...t_m on the course of the typhoon's motion. The selection of Δt is related to the typhoon's motion and the point spacing along the main directional line. But generally, for ease of calculation, using 1 hr is appropriate. If the typhoon's motion is slow, and when ΔF along the main directional line is larger, then the value Δt ought to be a bit larger, for example 1.5 or 2 hrs. (It is 1 hr in this example.)

As for the points t_0 and t_m; they can be determined within the stipulated range of effective winds by use of the special rule. When the typhoon center moves to t_0, the point F_0 begins to receive the influence of the effective winds and when the center reaches t_m, the point 0 just escapes the influence of the effective winds. Then within the range t_0-t_m, the other points t_1, t_2, ...t_{m-1} are gotten according to the above principles.

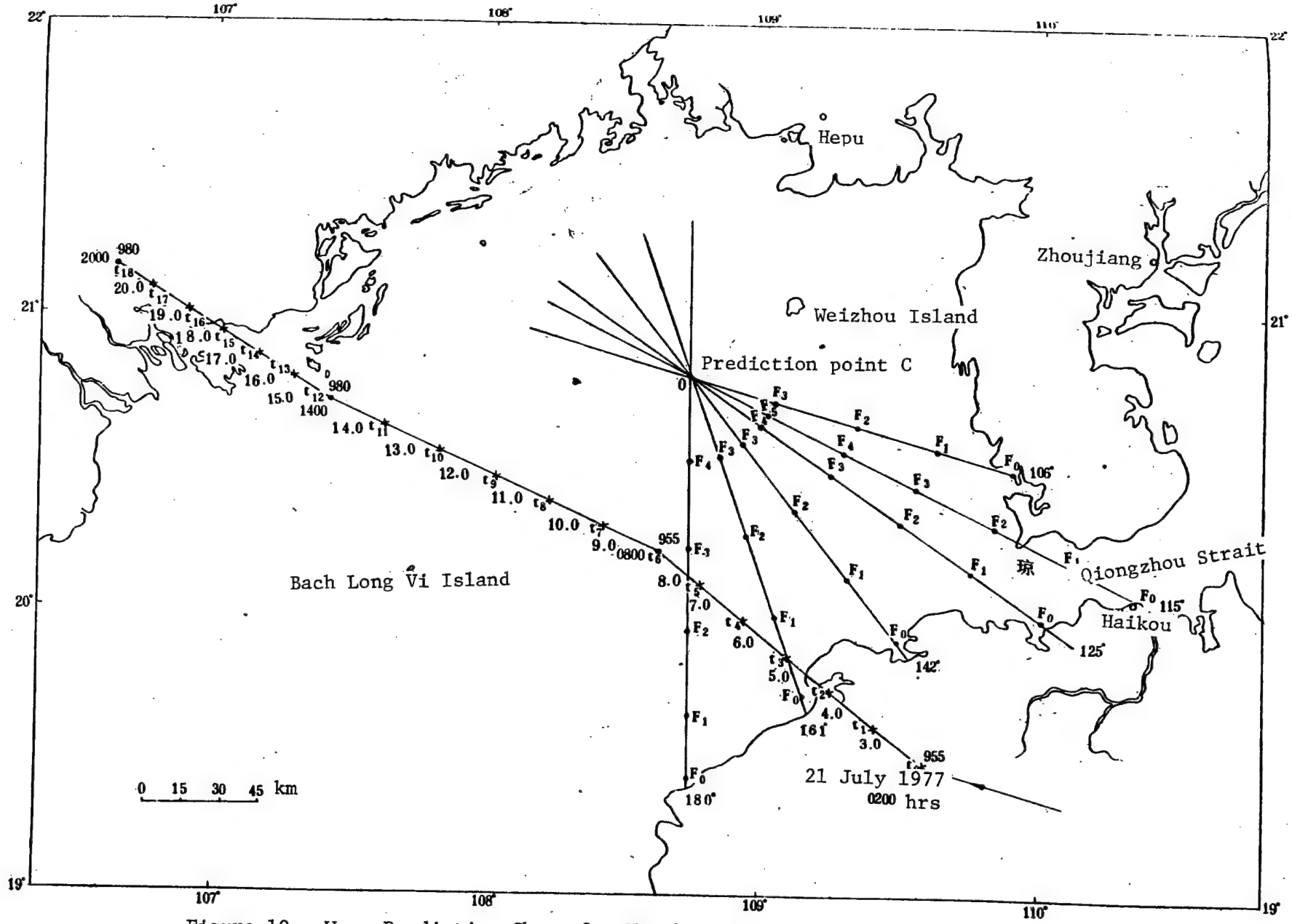


Figure 10. Wave Prediction Chart for North Tonkin Gulf Station C on 21 July 1977

Table 3a. Calculation Table for Prediction of Wind Speed at Station C on 21 July 1977 (Principle direction 115°)

F_n	t_m	t (hrs)	P_0 (Millibars)	r latitude distance	V'(m/s)	α(°)	cos α	V m/s	$\bar{V}_{t_m-t_{m+1}}$ (m/s)	$\bar{V}_{t_m-t_{m+1}}$ (m/s)
	t_1	3.0	955	1.05	29.6	13	0.974	28.8		
	t_2	4.0	955	1.15	28.6	23	0.921	26.6	27.0	
F_0	t_3	5.0	955	1.27	28.4	30	0.866	23.6	24.2	24.8
	t_4	6.0	955	1.40	27.4	35	0.819	22.3	22.6	22.9
	t_1	3.0	955	0.91	30.6	1	1.000	30.6		
	t_2	4.0	955	0.96	30.3	10	0.985	29.8	30.0	
F_1	t_3	5.0	955	1.06	29.6	22	0.927	27.4	27.9	28.3
	t_4	6.0	955	1.17	28.7	29	0.870	25.0	25.5	26.0
(F_0—F_1 33 km)	t_5	7.0	955	1.30	27.8	35	0.819	22.8	23.2	23.7
	t_2	4.0	955	0.83	31.1	8	0.991	30.8		
	t_3	5.0	955	0.86	31.0	7	0.993	30.8	30.8	
F_2	t_4	6.0	955	0.95	30.4	18	0.951	28.9	29.1	29.4
	t_5	7.0	955	1.07	29.4	28	0.883	26.0	28.6	27.1
(F_0—F_2 66 km)	t_6	8.0	955	1.20	28.5	35	0.819	23.4	23.9	24.5
	t_3	5.0	955	0.75	31.6	15	0.966	30.5		
	t_4	6.0	955	0.76	31.6	0	1.000	31.6	31.3	
F_3	t_5	7.0	955	0.83	31.1	14	0.970	30.2	30.5	30.7
	t_6	8.0	955	0.94	30.4	25	0.906	27.5	28.1	28.6
(F_0—F_3 99 km)	t_7	9.0	959	1.12	28.1	32	0.848	23.2	24.0	24.8
	t_4	6.0	955	0.70	31.9	20	0.940	30.0		
	t_5	7.0	955	0.70	31.9	5	0.996	31.8	31.3	
F_4	t_6	8.0	955	0.75	31.6	11	0.982	31.0	31.2	31.2
	t_7	9.0	959	0.88	29.8	22	0.927	27.6	28.3	28.9
(F_0—F_4 132 km)	t_8	10.0	963	1.07	27.4	30	0.866	23.8	24.6	25.3
	t_4	6.0	955	0.74	31.7	46	0.695	22.0		
	t_5	7.0	955	0.66	32.1	30	0.866	27.8	26.0	
F_5	t_6	8.0	955	0.63	32.2	12	0.978	31.5	30.4	29.3
	t_7	9.0	959	0.70	30.8	4	0.998	30.7	30.9	30.8
(F_0—F_5 165 km)	t_8	10.0	963	0.83	29.0	17	0.956	27.7	28.3	28.8
	t_5	7.0	955	0.75	31.6	55	0.574	18.1		
O	t_6	8.0	955	0.64	32.2	42	0.743	23.9	22.2	
	t_7	9.0	959	0.62	31.2	22	0.927	29.0	27.5	26.0
(F_0—O 198 km)	t_8	10.0	963	0.68	29.8	2	0.999	29.8	29.6	29.0

Table 3b. Calculation Table for Prediction of Waves at Station C on 21 July 1977 (Principal direction 115°)

Sequence	Symbol	Item	Calculation of marine waves											
			Calculating from F_0, t_1						Calculating from F_0, t_1					
①	ΔF (km)	Wind region segments used for projection of waves. In the example these are 33 km.	seg 1	seg 2	seg 3	seg 4	seg 5	seg 6	seg 1	seg 2	seg 3	seg 4	seg 5	seg 6
			F_0–F_1	F_1–F_2	F_2–F_3	F_3–F_4	F_4–F_5	F_5–O	F_0–F_1	F_1–F_2	F_2–F_3	F_3–F_4	F_4–F_5	F_5–O
②	$H_{\frac{1}{10}}$ (m)	The initial wave height of this segment. Taken from row 11 of previous segment.	0	3.7	5.6	6.2	6.6	7.3	0	4.2	5.1	5.7	6.0	6.6
③	$\bar{V}$ (m/s)	Average wind speed in this time segment and wind region segment, i.e., 28.6 m/s in the table is the average of the wind speed at F_2 and F_3 between t_4 and t_5.	t_1–t_2	t_2–t_4	t_4–t_5	t_5–t_6	t_5–t_6	t_6–t_7	t_2–t_4	t_4–t_5	t_5–t_6	t_6–t_7	t_7–t_8	t_8
			28.5	27.7	28.6	29.7	30.8	29.2	24.5	24.9	26.0	26.2	26.5	28.8
④	t_e (hrs)	Equivalent wind time. Looked-up in Figure 9 from values in rows ② and ③.	0	1.1	2.3	2.8	2.6	3.7	0	1.9	2.6	3.4	3.3	3.0
⑤	F_e (km)	Equivalent wind region. Looked-up in Figure 9 from values in rows ② and ③.	0	24	62	83	74	107	0	42	64	95	90	81
⑥	Δt (hrs)	Wind time for this segment. The time interval from previous segment row ⑬ to the instant after participating in the calculation of wind speed for this segment, i.e., 1.4 is the interval between 5.6 and 7.	1.0	2.0	1.4	1.5	0.7	1.0	2.0	1.0	1.0	1.1	1.3	0.5
⑦	$\Delta F'$ (km)	Wind region for this segment. The distance from previous segment row ⑭ to the calculation point after participating in the calculation of wind speed for this segment, i.e., 33 is the distance between 66 and 99 F_3.	33	46	33	33	33	37	33	33	33	33	33	33
⑧	t (hrs)	Wind time. Row ④ + row ⑥.	1.0	3.1	3.7	4.3	3.3	4.7	2.0	2.9	3.6	4.5	4.6	3.5
⑨	F (km)	Wind region. Row ⑤ + row ⑦.	33	70	95	116	107	144	33	75	97	128	123	114
⑩	$\bar{h}$ (m)	Average water depth within this wind region segment.	40	20	20	20	25	35	40	20	20	20	25	35
⑪	$H_{\frac{1}{10}}$ (m)	Wave height. Looked-up in Figure 9 based on values in rows ③, ⑧, ⑨, and ⑩.	3.7	5.6	6.2	6.6	7.3	7.9	4.2	5.1	5.7	6.0	6.6	7.3
⑫	$\bar{T}$ (sec)	Average wave period. Looked-up in Figure 9 based on values in rows ③, ⑧, ⑨, and ⑩.	6.9	8.4	8.9	9.2	9.6	10.1	7.3	8.0	8.5	8.7	9.1	9.7
⑬	T (hrs)	Instant of arrival. If the waves are determined by wind time, this is the instant after the calculation of wind speed for this segment, i.e., the time the waves arrive. If the waves are determined by wind area then this is gotten by subtracting row 8–t_{min} from the next time.	4.0	5.6	6.5	7.3	8.0	8.7	6.0	7.0	7.9	8.7	9.5	10.3
⑭	P (km)	Arrival point. Distance from the initial calculating point. Similar to row ⑬, whether the predicted value is determined by wind region is taken into consideration.	20	66	99	132	161	198	33	66	99	132	165	198

Table 3c. Calculation Table for Prediction of Wind Speeds and Marine Waves at Station C on 21 July 1977 (Principal direction 125°)

F_n	t_m	t (hrs)	P_o (millibars)	r latitude distance	V' (m/s)	α (°)	cos α	V (m/s)	$\bar{V}_{t_m - t_{m+1}}$ (m/s)	$\bar{V}_{t_m - t_{m+1}}$ (m/s)
	t_2	4.0	955	0.77	31.5	10	0.985	31.0		
	t_3	5.0	955	0.90	30.7	22	0.927	28.5	29.0	
F_0	t_4	6.0	955	1.05	29.6	30	0.866	24.6	25.4	26.1
	t_2	4.0	955	0.65	32.2	11	0.982	31.6		
	t_3	5.0	955	0.72	31.7	5	0.996	31.6	31.6	
F_1	t_4	6.0	955	0.82	31.2	18	0.951	29.7	30.1	30.4
	t_5	7.0	955	0.96	30.3	28	0.883	26.8	27.4	27.9
	t_6	8.0	955	1.12	29.1	35	0.819	23.9	24.5	25.1
	t_3	5.0	955	0.62	32.3	20	0.940	30.4		
	t_4	6.0	955	0.65	32.2	3	0.999	32.2	31.6	
F_2	t_5	7.0	955	0.74	31.6	13	0.974	30.8	31.1	31.2
	t_6	8.0	955	0.88	30.8	25	0.906	27.9	28.5	29.0
	t_7	9.0	959	1.06	28.5	30	0.866	24.7	25.3	25.9
	t_4	6.0	955	0.60	32.4	27	0.891	28.9		
	t_5	7.0	955	0.60	32.4	12	0.978	31.7	30.8	
F_3	t_6	8.0	955	0.67	32.1	8	0.991	31.8	31.8	31.5
	t_7	9.0	959	0.83	30.0	18	0.951	28.5	29.2	29.7
	t_8	10.0	963	1.03	27.7	26	0.899	25.0	25.7	26.4
	t_5	7.0	955	0.61	32.3	39	0.777	25.1		
	t_6	8.0	955	0.58	32.4	20	0.940	30.5	28.9	
F_4	t_7	9.0	959	0.66	31.0	3	0.999	31.0	30.9	30.3
	t_8	10.0	963	0.80	29.1	11	0.982	28.6	29.1	29.4
	t_9	11.0	967	0.97	27.0	21	0.932	25.1	25.8	26.5
	t_6	8.0	955	0.63	32.2	50	0.643	20.7		
	t_7	9.0	959	0.63	31.1	30	0.866	26.9	25.1	
O	t_8	10.0	963	0.67	29.8	11	0.982	29.3	28.5	27.5
	t_9	11.0	967	0.78	28.1	4	0.998	28.0	28.3	28.3

Calculating from F_0, t_2						
①	ΔF	F_0—F_1	F_1—F_2	F_2—F_3	F_3—F_4	F_4—O
②	$H_{\frac{1}{10}}$	0	4.1	5.9	6.5	7.3
③	$\bar{V}$	t_2—t_3 30.3	t_3—t_5 29.6	t_4—t_5 31.0	t_5—t_6 30.4	t_6—t_7 28.0
④	t_e	0	1.1	2.1	2.5	4.2
⑤	Fe	0	25	58	73	122
⑥	Δt	1.0	2.0	0.6	1.0	1.0
⑦	ΔF'	33	45	33	42	33
⑧	t	1.0	3.1	2.7	3.5	5.2
⑨	F	33	70	91	115	155
⑩	$\bar{h}$	30	20	20	25	35
⑪	$H_{\frac{1}{10}}$	4.1	5.9	6.5	7.3	7.9
⑫	$\bar{T}$	7.2	8.7	9.1	9.7	10.1
⑬	T	5.0	6.4	7.0	8.0	9.0
⑭	P	21	66	90	132	165

Calculating from F_0, t_3				
F_0—F_1	F_1—F_2	F_2—F_3	F_3—F_4	F_4—O
0	3.6	5.4	6.1	6.7
t_3—t_4 27.8	t_4—t_6 27.1	t_5—t_7 27.8	t_6—t_7 30.1	t_7—t_8 28.8
0	1.1	2.3	2.2	3.0
0	23	63	58	80
1.0	2.0	1.5	0.6	1.0
33	47	33	33	42
1.0	3.1	3.8	2.8	4.0
33	70	96	91	122
30	20	20	25	35
3.6	5.4	6.1	6.7	7.5
6.8	8.3	8.8	9.2	9.8
6.0	7.5	8.4	9.0	10.0
19	66	99	123	165

This is the same as in the previous description, however, since the method of gradual shift is used in calculation of the waves, for each point in F_0, F_1, ...0 one need not get the values of α and r for every time. Rather it is acceptable just to do the calculations based on four to six time points near the calculation point (see Table 3a).

3. Supplementary explanation for Table 3

Following the motion of the typhoon, in order to calculate the marine waves piece-wise on the selected main directional line, it is necessary to find the average wind speed value within the different time intervals for each wind area section. At the same time, since the changes in waves on the main directional line are continuous, when calculating the wind elements the adopted times and positions also ought to be continuous.

Below, with the calculation process for wind and wave elements beginning from F_0, t_1 in Table 3b as example, the problem of how to partition and produce continuous change is explained.

From the wave calculations for F_1-F_2 in the second row we know the time when the wave reaches point F_2 is 5.6 hrs. So when calculating the next wave it is necessary to begin from F_2 on the main directional line and in calculating the time it is also necessary to begin from 5.6 hrs. Here we determine the point separation (ΔF) on the projected main directional line with respect to the selection of wind area segments. That is, from F_2 to F_3 the selection of time interval obviously ought to begin at 5.6 hrs and stop when the calculation point F_3 is reached. But for convenience of calculation, here the time point t_4 (6 hrs) closest to 5.6 hrs serves as start for the calculation of average wind speed for the section and the next time point, t_5 serves as end point. Actually, since the time interval is short, the error caused by this sort of process is very small.

According to this, from Table 3a we can pick out the average wind speed for the two points F_2 and F_3 in the time interval t_4-t_5 (26.6 and 30.5 m/s), where the arithmetic mean is 28.6 m/s. This is the average wind speed we require to project calculation point F_3. If, as before, the waves are determined by the wind time, then the process of selection of its wind area segment and the selection of wind time segments described above are similar.

Obviously, the length of the wind area in the above example is 33 km and as for wind time, aside from the 1 hr time interval t_4-t_5, the time interval from 5.6 - 6 (0.4 hrs) must be added in before its continuity can be preserved. If this value and the effective wind time and effective wind area for the previous segment's waves are added together, then the wind elements for the waves projected at calculation point F_3 are obtained and the wave elements are sought. By this the calculation point is sought out gradually.

It is not hard to see that because the beginning time and position used are not the same as the main directional line selected to predict the waves, the wave elements obtained for the calculation point also are not completely identical. For this reason, in order to get the elements of the largest

waves at the calculation point during the time of influence by the effective winds, it is necessary to repeat the above calculation selecting different main directional lines and changes in the beginning time and position (as in Table 3b and Table 3c), finally determining the elements of the largest wave at the calculation point.

According to the steps above, for station C in the Tonkin Gulf we predicted the largest $H_{\frac{1}{10}}$ waves of 7.9 m, average period 10.1 seconds, main direction southeast at 8.7 and 9 in the morning on the day of the typhoon.

III. Testing and Comparisons

In order to test the predictive results of the method for typhoon waves, we selected observed data which was reliable and relatively representative from observations actually made of typhoon waves at the A and B stations of Hainan Island, stations C and D in the Tonkin Gulf, and station E in Guangdong Province for testing. Separately, comparisons were done against predicted results according to the other methods.

For wave prediction in the shallow marine areas of the Tonkin Gulf, both the standard method and our method were looked-up according to the actual average water depth and after getting deep water waves from the methods of Unoki and Bretschneider they were similarly corrected to shallow water waves using Figure 9. (Footnote 6) (See relevant material from the Shandong Oceanography Academy.)

(i) Results of testing and comparisons

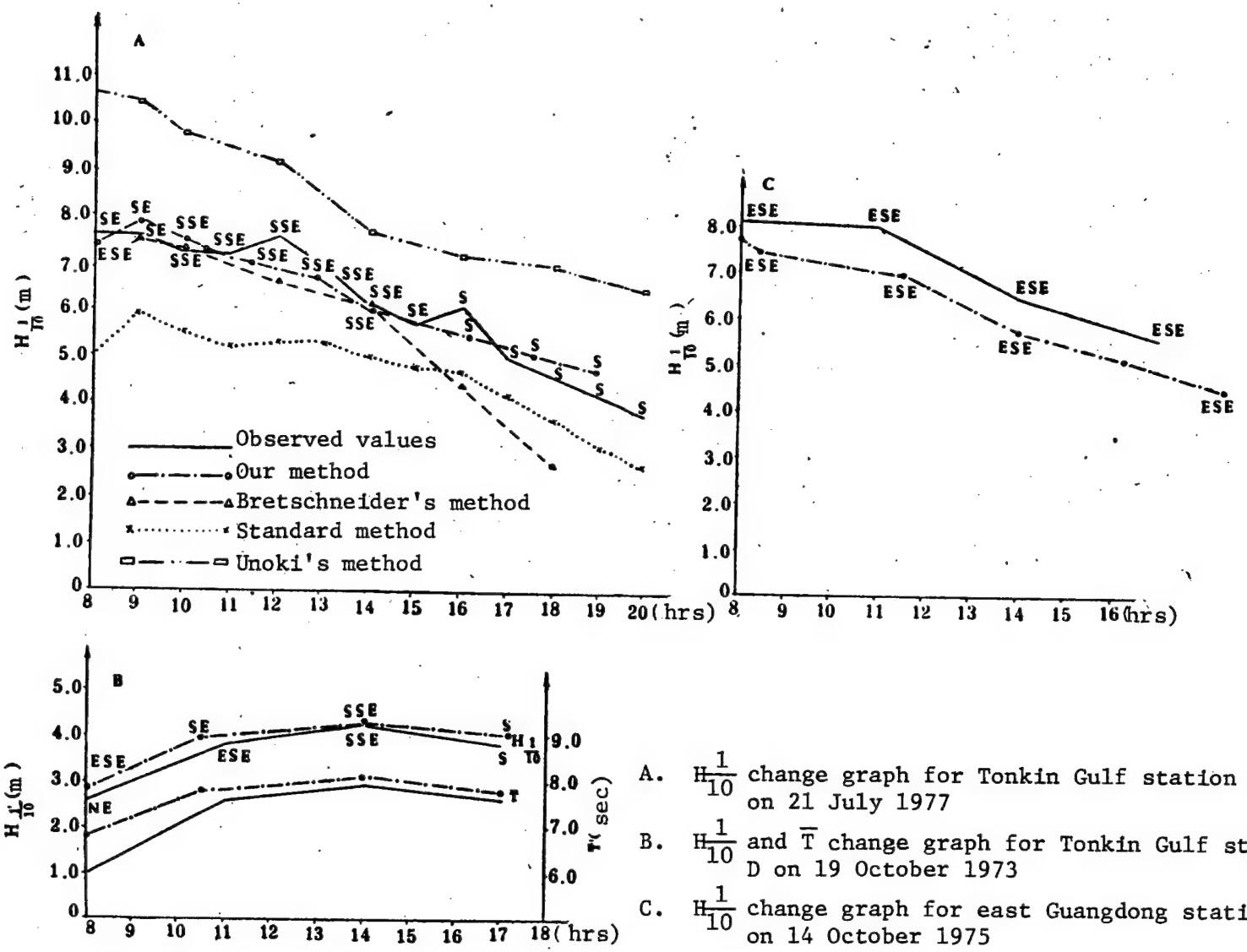
It is easy to see from Table 4 and Figure 11(a), (b), and (c) that the results obtained from the method introduced in this paper for predicting typhoon waves are quite good. In testing against 26 times in 6 typhoons, the relative error in wave periods was at most 12 percent and averaged 6 percent while the relative error in wave periods was at most 25 percent and averaged 10 percent. Moreover, during the course of typhoon motion, apart from the changing trends over time in the predicted values and in the observed values being nearly the same, the predicted waves (i.e., the predicted wave direction) and observed wave direction as well as their changing conditions over time were also quite close.

Table 4 and Figure 11a compare the predicted results of each method. For wave heights, the results of Unoki's method tend to be high (on average 34 percent higher than observed), the results of the standard method tend to be low (on average 16 percent lower than observed), and Bretschneider's method, although giving better results under many conditions, has some rather high errors between predicted and observed values. Separately, based on comparison with instrumentally observed periods, it is clear that nearly all of the predicted values from the various methods are larger than the observed values. The deviation is largest for Unoki's method, followed by Bretschneider's, and our method turns out to have the smallest largest relative error in predicting periods.

*(1) Coastal optical
(2) Ultrasonic numerical

Table 4. Comparison of Predicted and Observed Wave Element Values

Station	A	A	A	A	B	B	B
Year	1965	1965	1966	1966	1976	1976	1977
Month/day	7-15	7-15	7-26	7-26	9-21	9-21	7-21
Time	1400	1700	1100	1400	0200	0800	2000
Water depth (m)	10.0	10.0	10.0	10.0	11.1	11.5	11.0
Observing instrument*	(1)	(1)	(1)	(1)	(2)	(2)	(2)
Observed							
$H_{\frac{1}{10}}$ (m)	2.9	3.4	2.9	3.0	2.5	1.9	2.3
$\overline{T}$ (sec)	5.3	6.0	6.8	6.8	5.8	5.8	6.9
Our method							
$H_{\frac{1}{10}}$ (m)	2.8	3.2	2.9	2.9	2.7	2.0	2.2
$\overline{T}$ (sec)	6.6	7.0	6.7	6.7	7.1	6.3	3.0-9.6
Standard method							
$H_{\frac{1}{10}}$ (m)	2.9	3.2	2.8	3.0	2.4	1.7	
$\overline{T}$ (sec)	6.7	6.9	6.5	6.8	6.4	5.2	
Bretschneider							
$H_{\frac{1}{10}}$ (m)	3.1	3.7	3.1	2.9	2.7	2.3	
$\overline{T}$ (sec)	9.9	9.8	9.6	9.5	8.4	7.8	
Unoki							
$H_{\frac{1}{10}}$ (m)	4.1	4.2	3.8	3.8	3.1	2.5	
$\overline{T}$ (sec)	8.8	8.8	8.7	8.6	8.5	8.2	
Our method							
$\frac{\Delta H}{H}$ (percent)	- 3	- 6	0	- 3	+ 8	+ 5	- 4
$\frac{\Delta \overline{T}}{\overline{T}}$ (percent)	+25	+17	- 1	- 1	+22	+ 9	--
Standard method							
$\frac{\Delta H}{H}$ (percent)	0	- 6	- 3	0	- 4	-11	
$\frac{\Delta \overline{T}}{\overline{T}}$ (percent)	+27	+15	- 4	0	+10	-10	
Bretschneider							
$\frac{\Delta H}{H}$ (percent)	+ 7	+ 9	+ 7	- 3	+ 8	+21	
$\frac{\Delta \overline{T}}{\overline{T}}$ (percent)	+87	+63	+41	+40	+45	+41	
Unoki							
$\frac{\Delta H}{H}$ (percent)	+41	+24	+31	+27	+24	+32	
$\frac{\Delta T}{T}$ (percent)	+66	+47	+28	+26	+47	+41	



A. $H\frac{1}{10}$ change graph for Tonkin Gulf station C on 21 July 1977

B. $H\frac{1}{10}$ and $\overline{T}$ change graph for Tonkin Gulf station D on 19 October 1973

C. $H\frac{1}{10}$ change graph for east Guangdong station E on 14 October 1975

Figure 11. Graphs of the Changes in Calculated and Observed Wave Elements

(ii) Efficacy in actual application

The prediction method for the first type has been used in predicting waves for certain engineering tasks and at Hainan Island station B with rather good efficiency. When undertaking certain engineering jobs, our method was used to calculate 25 years of typhoon waves. A statistical comparison of the results from our method with short-term observed data showed no great discrepancy (see Table 5). For the waves predicted at station B we adopted two courses. One was to take the correlation of observed waves between station B and nearby station A, then convert the extreme value statistical results of the observed wave data for many years to wave values for station B. The other course was to predict 27 years of typhoon waves using our method and then do extreme value statistics. From Table 6 it can clearly be seen that the statistical results of both courses are quite close. For the region of the north Tonkin Gulf, the largest waves appearing at station B using our method were $H_{\frac{1}{10}}$ waves, 6.27 m high (average water depth 12 m), encountered once in 50 years. Doing frequency analysis on many years of actual data we got waves with the same reoccurrence interval at stations A and D with respective heights of 6.05 m, (average water depth 10 m) and 6.10 m (average water depth 11 m). (Footnote 7) (According to data from the Geology Department of Nanjing University.) The three results are very close.

Table 5. Predicted Values for 50 Year Bay Wave Elements

Elements \ Prediction point / Method		B	E	F
$H_{1\ percent}$ (m)	Prediction method statistical value		4.93	2.26
	--one year's observation statistical value		4.93	2.32
$H_{4\ percent}$ (m)	Same as above	4.38	4.21	2.00
		4.92	4.60	1.88
$H_{13\ percent}$ (m)	Same as above	3.59		
		3.63		
$\overline{T}$ (seconds)	Same as above	7.5		
		7.9		

Table 6. Predicted Values for Wave Elements at Station B

Method / $H_{\frac{1}{10}}$ (m) / Reoccurrence interval (yrs)	Direction: WNS-NNW 50	WNS-NNW 25	WNS-NNW 10	WSW 50	WSW 25	WSW 10
Prediction method statistical value	6.27	5.80	4.88	4.58	4.20	3.44
Correlation analysis statistical value	6.49	5.67	4.73	4.32	4.00	3.25

The prediction method for the second type of situation, although not yet used systematically, has also been used by Nanjing University for testing typhoon waves which influence certain islands. When completing certain engineering projects our institute also used this method to do some comparisons with good efficiency.

IV. Conclusion

Summing up the above, the procedure for applying our method to the first type situation is as follows: After determining the wind speed at different points on the main directional line (the course of the typhoon's motion), by a process of a sort of averaging the average wind speed of the wind-waves are calculated from which the wave elements are predicted. For the second type situation, after getting the average wind speed for each time interval and the corresponding wind segment, using the concept of effective wind elements, prediction is done gradually toward the prediction point. As a consequence of using different prediction methods for the different situations, the efficiency of the predictions is quite good. In addition, our method requires only little meteorological data (the position at different times of the typhoon center and the barometric pressure at the center) to be able to calculate typhoon waves.

However, our method used a radius of 0.6 latitude distance of maximum wind speeds for all typhoons. This assumption is in error for certain special typhoons. Moreover, all of the observed wind speeds were less than 27 m/s so under conditions of high wind speeds the calculated value can have a larger deviation. Apart from this, changes in wind speed brought about by the speed of motion of the typhoon itself, and the influence of land masses has not yet been seriously considered but rather have only been broadly generalized in the relationship of wind gradients and marine wind. With respect to concrete typhoons this is also not rigorous. These sorts of problems await future progress and perfection.

REFERENCES

1. Wen Shengchang, "Principles of Marine Waves," in Chinese, Shandong People's Press, 1962.

2. Ministry of Communications of the People's Republic of China, "Standards of Port Engineering Technology (Harbor Hydrology)," in Chinese, People's Communication Press, 1978.

3. Unoki, S., "Mean Distribution of Wave Heights and Periods," JOURNAL OF THE METEOROLOGICAL SOCIETY OF JAPAN, 35(5), (1957) 41-53.

4. Silvester, R., COASTAL ENGINEERING I, 123-126, Elsevier Scientific Publishing Company, 1974.

5. Bretschneider, Charles L., "A Nondimensional Stationary Hurricane Wave Model," Fourth annual offshore technical conference, 1 1972.

12966/9365
CSO: 4008/1062

FIELD IN SINGLE-MODE HELICALLY WOUND OPTICAL FIBERS

Beijing TONGXIN XUEBAO [JOURNAL OF CHINA INSTITUTE OF COMMUNICATIONS] in Chinese Vol 6 No 4, Oct 85 pp 70-75, 91

[Article by Fang Xisheng [2455 6932 3932] and Lin Zongqi [2651 1350 3823] of Shanghai Jiaotong University: "Field in Single-Mode Helically Wound Optical Fibers"; paper received 11 December 1984]

[Text] English abstract: The coupled-mode equations of the scalar field of the fundamental mode in single-mode helically wound optical fiber with circular cross-section are obtained by using the Maxwell equations in the local orthogonal curvilinear coordinate system introduced by Tang[3] and the weakly guiding boundary condition. Two main results are brought about via the perturbation expansion of the fields and the propagation constants:

1) The field in the afore-mentioned fiber maintains a quasi-linear state of polarization (SOP) while its orientation rotates with a rotation rate close to $-\tau$ with respect to the Serret-Frenet frame.

2) The SOP of the above field changes periodically along the propagation distance s from 1 to a value a little less than 1, and for a fixed s, it changes periodically according to the incident polarized angle with a period $\pi/2$.

The theoretical results are consistent with the published experimental data on liquidcore fibers.

I. Introduction

Regarding the problems of magnetic fields and wave propagation in a helix, it was Sollfrey[1] who first produced a general Maxwell equation for a waveguide of circular cross-section, and also an approximation. But what he produced was a non-orthogonal coordinate system, which makes specific handling rather difficult. Studies in differential geometry on the problem have generally used the Serret-Frenet frame[2]. But because this is not an orthogonal curvilinear coordinate system, Tang derived on this basis a local orthogonal curvilinear coordinate system for general spatial curves[3] (hereafter called the Tang coordinate system). On the basis of the Tang coordinate system, this paper obtains a more succinct magnetic field equation for

circular cross-sectioned single-mode helically-wound optic fiber. By perturbation expansion of the field and propagation constants, we have solved for the scalar coupled wave equation of the transverse field and have reached two specific conclusions:

(1) When helically wound optic fibers use linearly polarized light, the field within the optic fiber maintains a quasi-linearly polarized state, and its direction of polarity, in reference to the Serret-Frenet frame, will rotate at a rotation rate that approaches $(-\tau)$ with the propagation distance S (where τ is the deflection at the optic fiber centerline).

(2) The quasi-linearly polarized state mentioned above changes from 1 to somewhat less than 1 periodically with the propagation distance S; with a given location S, the emergent polarized state changes periodically with the incident polarity angle ϕ, where the period is $\pi/2$.

The conclusions just stated have been confirmed by the experimental results of Papp and Harms[4].

II. The Field Equations for the Tang Coordinate System and a Zero-Order Approximate Solution for Optic Fiber Fields

Figure 1 shows the coordinates of a circular cross-section of a cylindrical helical optic fiber. The center line in the optic fiber in the figures is a right hand helix. The radius of the cylinder is R_0 and the radius of the optic fiber is a, where

$$R_0 \gg a. \tag{2-1}$$

If the helical angle of the helix is σ, the pitch is h, the arc length is s, curvature is χ, and deflection is τ,

let
$$B = h/2\pi, \tag{2-2}$$

then
$$\chi = R_0/(R_0^2 + B^2),\ \tau = B/(R_0^2 + B^2) \tag{2-3}$$

$$\tau/\chi = B/R_0 = \tan\sigma \tag{2-4}$$

Let the tangent, the primary normal line, and auxiliary normal line of a point 0' on the helix be t, n and b, and their respective unit vectors be a_t, a_n and a_b. We call $0'-(a_t, a_n, a_b)$ the Serret-Frenet frame of the curve. When $\tau \neq 0$, this frame is no longer an orthogonal curvilinear coordinate system in the neighborhood of the curve[5]. On the basis of this frame, Tang derived a group of new coordinates s, m, and p, the unit vectors of a_s, a_m and a_p having a relational expression to the original unit vectors (Figure 2):

$$a_s = a_t \tag{2-5}$$

$$a_m = a_n \cos\psi(s) + a_b \sin\psi(s) \tag{2-6}$$

$$a_p = -a_n \sin\psi(s) + a_b \cos\psi(s) \tag{2-7}$$

where, $$d[\psi(s)]/ds=-\tau(s) \tag{2-8}$$

For the helix there is: $$\psi=-Bs/(R_0^2+B^2) \tag{2-9}$$

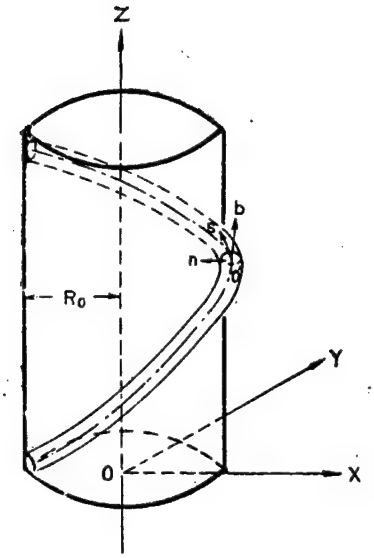


Figure 1. The Geometric Structure and Coordinate System of a Circular Cross Section Cylindrical Helically Wound Fiber Optic

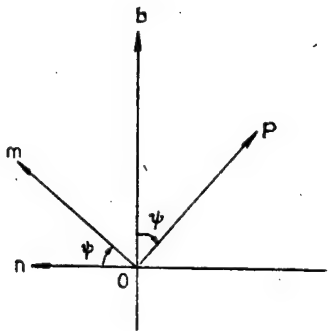


Figure 2. The Serret-Frenet Frame and Tang Coordinate System

Tang has proven the orthogonal nature of $0'-(a_r, a_m, a_p)$ for the coordinate system, where the metric coefficient is

$$h_m=h_p=1,\ h_s=1-\chi[m\cos\psi-p\sin\psi] \tag{2-10}$$

Exchanging the coordinates m and p for the polar coordinates r and θ:

$$m=r\cos\theta,\ p=r\sin\theta \tag{2-11}$$

The corresponding metric coefficient is:

$$h_r=1,\ h_\theta=r,\ h_s=1-\chi r\cos(\theta+\psi) \tag{2-12}$$

Because ψ is a function of s, there is a relation between h_S and s. When $\tau=0$, $\psi=0$, and $\chi=1/R_0$, the helix recedes to a ring of radius R_0, the metric coefficient for which is

$$h_r=1,\ h_\theta=r,\ h_s=1-\frac{r}{R_0}\cos\theta \tag{2-13}$$

We can see from the foregoing analysis that when $\tau\neq 0$, the difference between the Tang coordinate system and the circular coordinate system when $\tau=0$ is when the former increases with s and rotates relative to the Serret-Frenet frame.

The rate of rotation is the rotation angle of unit length at -τrad. At this time, let a given curve (m_0, p_0, s) $[(m_0, p_0) \neq (0,0)]$ be a helix spiraling around the s axis.

As for the electrical and magnetic field vectors E and H, these can be resolved in the Tang coordinate system as:

$$\boldsymbol{E} = E_m \boldsymbol{a}_m + E_p \boldsymbol{a}_p + E_s \boldsymbol{a}_s, \quad \boldsymbol{H} = H_m \boldsymbol{a}_m + H_p \boldsymbol{a}_p + H_s \boldsymbol{a}_s \tag{2-14}$$

When each component of an electric field is known, then each component of the magnetic field can be derived by a Maxwell equation in the Tang coordinate system:

$$H_m = [\partial(h_s E_s)/\partial p - \partial E_p/\partial s]/(-j\omega\mu \cdot h_s) \tag{2-15}$$

$$H_p = [\partial E_m/\partial s - \partial(h_s E_s)/\partial m]/(-j\omega\mu \cdot h_s) \tag{2-16}$$

$$H_s = [\partial E_p/\partial_m - \partial E_m/\partial p]/(-j\omega\mu_0) \tag{2-17}$$

Below, we discuss the wave equation that satisfies the electric field vectors

$$(4 + n^2 k_0^2)\boldsymbol{E} = 0 \tag{2-18}$$

where, n is dielectric refractivity and k_0 is the wave number in free space. From the vector identity

$$\Delta \boldsymbol{E} = \nabla(\nabla \cdot \boldsymbol{E}) - \nabla \times (\nabla \times \boldsymbol{E}), \tag{2-19}$$

we can pass the transverse field equation (2-18)

$$[(A + n^2 k_0^2)\boldsymbol{E}]_m = 0, \quad [(A + n^2 k_0^2)\boldsymbol{E}]_p = 0 \tag{2-20}$$

through a few operations to directly write the group of scalar coupled equations:

$$\left[\left(\frac{\partial^2}{\partial m^2} + \frac{\partial^2}{\partial p^2} + \frac{1}{h_s^2}\frac{\partial^2}{\partial s^2} + n^2 k_0^2\right) + \chi\left(-\cos\psi \frac{\partial}{\partial m} + \sin\psi \frac{\partial}{\partial p}\right)h_s^{-1} + \chi^2(-\cos^2\psi \cdot h_s^{-2} + \tan\sigma(m\sin\psi + p\cos\psi)h_s^{-3}\frac{\partial}{\partial s}\right)\Big]E_m + \frac{1}{2}\chi^2 \sin 2\psi \cdot h_s^{-2} E_p + \Big[2\chi h_s^{-2}\cos\psi \frac{\partial}{\partial s} + \chi^2 \tan\sigma h_s^{-2}\sin\psi - \chi^3 \tan\sigma h_s^{-3}\sin\psi \cdot (m\sin\psi + p\cos\psi)\Big]E_s = 0 \tag{2-21}$$

$$\left[\left(\frac{\partial^2}{\partial m^2} + \frac{\partial^2}{\partial p^2} + \frac{\partial^2}{h_s^2 \partial s^2} + n^2 k_0^2\right) + \chi\left(-\cos\psi \frac{\partial}{\partial m} + \sin\psi \frac{\partial}{\partial p}\right)h_s^{-1} + \chi^2\left(-\sin^2\psi \cdot h_s^{-2} + \tan\sigma\,(m\sin\psi + p\cos\psi)h_s^{-3}\frac{\partial}{\partial s}\right)\Big]E_p + \frac{1}{2}\chi^2 \sin 2\psi h_s^{-2} E_m + \Big[-2\chi h_s^{-2}\sin\psi \frac{\partial}{\partial s} + \chi^2 \tan\sigma h_s^{-2}\cos\psi + \chi^3 \tan\sigma \cos\psi h_s^{-3}(m\sin\psi + p\cos\psi)\Big]E_s = 0 \tag{2-22}$$

We know from (2-1) that $\chi_a \ll 1$, (2-23)

Therefore, the lateral coupling between the components E_m and E_p of the electric fields in (2-21) and (2-22) is the least value of the $(\chi_a)^2$ order value, and also the coupling factor is $(\chi_a)^2 \sin 2\psi / 2h_z$, therefore the coupling cannot accumulate with the propagation distance S.

Given that the optic fiber is weakly guiding, i.e., its relative refringence is $\Delta \ll 1$, at that time the longitudinal field is only a $(\Delta^{\frac{1}{2}})$ order value[6].

Therefore, not considering the relation between the propagation constant and the polarized surface, by making a zero-order approximation of (2-21) and (2-22) satisfying E_m and E_p, we get

$$(\nabla_t^2 + n^2 k_0^2 - \beta_0^2) E_{0m} = 0 \tag{2-24}$$

$$(\nabla_t^2 + n^2 k_0^2 - \beta_0^2) E_{0p} = 0 \tag{2-25}$$

in which, E_{0m}, E_{0p}, and β_0 are the zero order values for the transverse fields E_m, E_p, and the propagation constant β, respectively, and the transverse Laplace operator is:

$$\nabla_t^2 = \left(\frac{\partial^2}{\partial \rho^2} + \frac{1}{\rho} \frac{\partial}{\partial \rho} + \frac{1}{\rho^2} \frac{\partial^2}{\partial \theta^2} \right) \Big/ a^2 \tag{2-26}$$

Here, ρ is the normalized radial coordinate $\rho = r/a$ (2-27)

The zero-order fields prove that with a polarized surface in a transforming state of linear polarity, the distribution of field amplitude is the same as with straight optic fiber.

As described above, only in Tang coordinates can coupling be maintained between two transverse electrical field components E_m and E_p at a second order increment, and also not accumulate with the propagation distance, consequently maintaining a quasi-linearly polarized state. This conclusion has been proven in tests with liquid core optic fibers. Reference [4] provides real test data as evidence: after helical optic fibers have made one turn where σ is $\pi/4$, $B = R_0, S = 2\sqrt{2}\pi R_0$, from which we get $\psi = -\sqrt{2}\pi \, rad = -254°$.

III. Type Postulation and the Perturbation Method

Because our discussion is entirely based upon the rotational Tang coordinate system, the fields of helical optic fibers have characteristics within that maintain their polarity. Therefore, when going on to use the method of perturbation analysis to discuss the characteristics of helical optic fiber fields, we must base this on the Tang coordinates and produce type postulation. In other words, we base the rest of the following discussion on Maxwell equations within the Tang coordinate system, and the scalar wave equations for field components are also in light of the components of the Tang coordinates.

When proceeding from zero-order approximations to seeking a first order field solution regarding the lesser parameter χ_a, we must consider the perturbation expansion of the propagation constant. The first order lesser value of the field will lead to a correction of the second order lesser value of the propagation constant. This kind of correction is similar to the double refraction in purely curving (τ=0) optic fiber, and the effect it has on fields is that there will be accumulation through the propagation distance s. Perturbation analysis of the propagation constant depends upon accurate type postulation, while type postulation depends on field boundary conditions. We can see from the type of purely curving optic fibers[7] that the two fundamental types of orthogonal linear polarity reached strictly according to boundary conditions will be parallel to the main and auxiliary normal lines a_n and a_b, respectively. Under conditions where the deflection τ is not 0, as s increases, the field component directions corresponding to a_n (or a_b) will rotate at the rate of rotation $-\tau$. Therefore, in the Tang coordinate system, when we can only seek for the propagation constant for the fields for the linear polarity along a_m and a_p when a_m and a_p have rotated to the same direction as a_n and a_b. Under normal conditions, the polarity of a field is definitely not the same as the direction of a_n or a_b. At these times, we must resolve for the fields at each value of s two polarized states parallel at these locations with the directions of a_n and a_b, such that they propagate by different propagation constants.

Let E_m^n and E_p^b be a_m and a_p, respectively, when they have rotated to the same directions as a_n and a_b, and list their perturbation expansion according to the distribution function of the electric fields of a_m and a_p:

$$E_m^n\exp(-j\beta_n s)=(E_{0m}^n+\epsilon E_{1m}^n+\cdots)\exp(-j\beta_n s) \tag{3-1}$$

$$E_p^b\exp(-j\beta_b s)=(E_{0p}^b+\epsilon E_{1p}^b+\cdots)\exp(-j\beta_b s) \tag{3-2}$$

$$\beta_n^2=\beta_0^2(1+\epsilon^2\beta_{2b}+\cdots) \tag{3-3}$$

$$\beta_b^2=\beta_0^2(1+\epsilon^2\beta_{2b}+\cdots) \tag{3-4}$$

Here,

$$\epsilon=2\beta_0^{\frac{1}{2}}a^2\chi_a \tag{3-5}$$

It must be pointed out that E_m^n and E_p^b are stationary in relation to a_m and a_p. Notice that at this time $\psi=2k\pi(k=0,\ \pm1,\ \pm2,\ \cdots)$. We know from (2-21) and (2-22) that E_m^n and E_p^b satisfy the equations[8]:

$$Q^2[\nabla_t^2+n^2k_0^2-\beta_n^2/(1-\chi_r\cos\theta)^2]E_m^n=\chi_a\left\{\left[\cos\theta\frac{\partial}{\partial\rho}-\frac{\sin\theta}{\rho}\frac{\partial}{\partial\theta}\right]E_m^n/(1-\chi_r\cos\theta)+2j\beta_0 aE_z^n/(1-\right.$$

$$\left.-\chi_r\cos\theta)^2\right\}+O[(\chi_a)^2] \tag{3-6}$$

$$Q^2[\nabla_t^2+n^2k_0^2-\beta_b^2/(1-\chi_r\cos\theta)^2]E_p^b=\chi_a\left\{\left[\cos\theta\frac{\partial}{\partial\rho}-\frac{\sin\theta}{\rho}\frac{\partial}{\partial\theta}\right]E_p^b/(1-\chi_r\cos\theta)\right\}+O[(\chi a)^2] \tag{3-7}$$

where, E_s^n indicates distribution of a longitudinal field when $\psi=2k\pi$.

In the two equations (3-6) and (3-7), the second order and higher order increments omitted include increments created because of a corresponding turning by a_n, a_b and a_m, and by a_p as s grows.

Substituting (3-1)--(3-4) in (3-6) and (3-7), the zero-order perturbation equations listed by the powers of ϵ are (2-24) and (2-25), and the first-order equations are:

$$a^2[\nabla_t^2+n^2k_0^2-\beta_0^2]E_{1m}^n=\rho E_{0m}\cos\theta+\left[\left(\frac{\partial E_{0m}}{\partial\rho}\cos\theta-\frac{\partial E_{0m}}{\partial\theta}\frac{\sin\theta}{\rho}\right)+2j\beta_0 aE_{0s}\right]/2\beta_0^2a^2 \tag{3-8}$$

$$a^2[\nabla_t^2+n^2k_0^2-\beta_0^2]E_{1p}^b=\rho E_{0p}\cos\theta+\left(\frac{\partial E_{0p}}{\partial\rho}\cos\theta-\frac{\partial E_{0p}}{\partial\theta}\frac{\sin\theta}{\rho}\right)/2\beta_0^2a^2 \tag{3-9}$$

Here, that the zero-order field appearing on the right is not written with an n or b is because they are not restricted by equations (3-1)--(3-4). The E_{0s} in equation (3-8) can be solved through Maxwell's equation in the Tang coordinate system.

To begin simplifying, we will only consider step-type refractive optic files, the refraction distribution of which is:

$$n=\begin{cases}n_1 & (\rho<1),\\ n_2 & (\rho>1),\end{cases} \tag{3-10}$$

From weakly guided boundary conditions we can posit β_0 as well as parameters

$$u^2=a^2(n_1^2k_0^2-\beta_0^2),\quad w^2=a^2(\beta_0^2-n_2^2k_0^2) \tag{3-11}$$

With polarized base nodes $HE_{11}^{(m)}$ and $HE_{11}^{(p)}$ input at locations s=0 and ψ=0, respectively, we get from (2-24) and (2-25):

$$E_{0m}^{(m)}=E_{0p}^{(p)}=\begin{cases}J_0(u\rho)/J_0(u), & (\rho<1);\\ K_0(w\rho)/K_0(w), & (\rho>1);\end{cases} \tag{3-12}$$

$$E_{0m}^{(p)}=E_{0p}^{(m)}=0 \tag{3-13}$$

From (3-8) and (3-9) is given:

$$E_{1m}^{n(m)}=\begin{cases}\cos\theta\left[\left(\frac{\rho^2}{4u}-C_1\right)J_1(u\rho)+\frac{3\rho J_0(u\rho)}{4\beta_0^2a^2}\right]\Big/J_0(u) & (\rho<1)\\ \cos\theta\left[\left(-\frac{\rho^2}{4w}-C_{1e}\right)K_1(w\rho)+\frac{3\rho K_0(w\rho)}{4\beta_0^2a^2}\right]\Big/K_0(w) & (\rho>1)\end{cases} \tag{3-14}$$

$$E_{1p}^{b(p)}=\begin{cases}E_{1m}^{n(m)}-\frac{\rho J_0(u\rho)}{2\beta_0^2a^2J_0(u)}\cos\theta & (\rho<1),\\ E_{1m}^{n(m)}-\frac{\rho K_0(w\rho)}{2\beta_0^2a^2K_0(w)}\cos\theta & (\rho>1)\end{cases} \tag{3-15}$$

$$E_{1m}^{n(p)}=E_{1p}^{b(m)}=0 \tag{3-16}$$

where, through boundary conditions C_1 and C_{1e} give:

$$C_1 = K_1(w)/4uK_0(w),\ C_{1e} = J_1(u)/4wJ_0(u) \tag{3-17}$$

Let A_∞ be a cross section of an optic fiber, where the center of the circle is the intersection 0' of the center line with the cross section and the radius is a sufficiently large (as for example $r=100a$) circle. Operations $\iint_{A_\infty}[E_m^{(m)}\times(2-24)-E_{0m}^{(m)}\times(3-6)]dA$ and $\iint_{A_\infty}[E_p^{(p)}\times(2-25)-E_{0p}^{(p)}\times(3-7)]dA$ were carried out at A_{10} using the Green integral theorem, we can separately derive β_{2n} and β_{2b}, consequently arriving at:

$$\Delta\beta=\beta_e-\beta_o=\beta_0^3(\chi_e)^2(\beta_{1e}-\beta_{1o})/2\beta_0$$

$$\approx\frac{(\chi_e)^2\beta_0^3a^2\iint_{A_\infty}[\beta_0^3a^2\,2p\cos\theta E_{0m}^{(m)}(E_{1p}^{(p)}-E_{0m}^{(m)})]/(1-\frac{a}{R_0}\rho\cos\theta)^2]dA}{2\beta_0\iint_{A_\infty}\left[a^2(E_{0m}^{(m)})^2/(1-\frac{a}{R_0}\rho\cos\theta)^2\right]dA}$$

$$\approx(\chi_e)^2\beta_0\left[\frac{1}{6}+(u^2-\omega^2)/3u^2w^2+J_0(u)/3uJ_1(u)\right] \tag{3-18}$$

Below, we have processed electric fields E_m and E_p under normal conditions. It can be seen that the method by which to analyze and handle twisted linear double refraction optic fiber is completely fitting in mathematical expression. The approximation of the latter has been discussed in detail in references [10] and [11].

Figure 3 shows the two coordinate systems used when handling twisted optic fibers[9]. One is a fixed orthogonal coordinate system, x,y,z with unit vectors of a_x, a_y, and a_z, and the Maxwell equation is then listed in this coordinate system. The other is the non-orthogonal coordinate system x',y',z parallel to the major and minor axes of the optic fiber local ellipsis, where the unit vectors are $a_{x'}$, $a_{y'}$, and a_z. In this coordinate system, because of its non-orthogonal nature, there is no way to list out a succinct Maxwell equation. Although the coordinates x' and y' are similar to the coordinates x and y in turning at a twisting rate a with the propagation distance z, at any location Z on the optic fiber we can still resolve any transverse field E_i into two components parallel with this location and $a_{x'}$ and $a_{y'}$, namely,

$$E_t=E_xa_x+E_ya_y=E_{x'}a_{x'}+E_{y'}a_{y'} \tag{3-19}$$

Also,

$$\begin{bmatrix}E_{x'}\\E_{y'}\end{bmatrix}=\begin{bmatrix}\cos az & \sin az\\-\sin az & \cos az\end{bmatrix}\begin{bmatrix}E_x\\E_y\end{bmatrix} \tag{3-20}$$

After these two components have propagated a short distance Δz in the direction of a_z in the x,y,z coordinate system based on the two propagation constants for linear double refraction optic fiber, we then use a conversion matrix to convert to x,y coordinates. Because the fields of optic fibers are weakly guiding, we use here a plane wave approximation.

We also use two coordinate systems for helical optic fibers. One is the Tang orthogonal coordinate system m,p,s, with unit vectors of a_m, a_p, a_s. The Maxwell equation is then established in this coordinate system, and only within this coordinate system can there be listed rather succinct scalar wave equations for field components. The other coordinate system is n,b,s with unit vectors of a_n, a_p, a_s. In this coordinate system, due to its non-orthogonal nature, there is no way to list out a succinct Maxwell equation. Although the coordinates n and b turn at a rate of rotation τ with the propagation distance S and in relation to the coordinates m and p, at any point S on the optic fiber, we can still resolve any transverse field E_1 into two components parallel with this location and a_p, a_b, e.g.,

$$E_t = A_m E_m a_m + A_p E_p a_p = A_n E_m^n a_n + A_b E_p^b a_b \tag{3-21}$$

Also,

$$\begin{bmatrix} A_n \\ A_b \end{bmatrix} = \begin{bmatrix} \cos\psi & -\sin\psi \\ \sin\psi & \cos\psi \end{bmatrix} \begin{bmatrix} A_m \\ A_p \end{bmatrix} \tag{3-22}$$

After these two components have propagated a short distance Δs along a_s in the coordinate system m,p,s, we can then convert with a conversion matrix to the m and p coordinates. We know from equation (3-15) that equation (3-22) omitted the first order difference of a field, but we still plan for the second order difference in the propagation constant, from which we get:

$$\frac{d}{ds}\begin{bmatrix} A_m \\ A_p \end{bmatrix} = -j \begin{bmatrix} \cos\psi & \sin\psi \\ -\sin\psi & \cos\psi \end{bmatrix} \begin{bmatrix} \beta_n & 0 \\ 0 & \beta_b \end{bmatrix} \begin{bmatrix} \cos\psi & -\sin\psi \\ \sin\psi & \cos\psi \end{bmatrix} \begin{bmatrix} A_m \\ A_p \end{bmatrix} \tag{3-23}$$

This can be converted through (3-22) and (3-23) to:

$$\begin{cases} dA_n/ds = -j\beta_n A_n + \tau A_b & (3\text{-}24a) \\ dA_b/ds = -j\beta_b A_b - \tau A_n & (3\text{-}24b) \end{cases}$$

Resolving (3-24) with the Laplace transform, we directly produce[10]:

$$A_n(s) = \{f\cos[\tau s/\sqrt{F}] + \sqrt{F}\left(if\frac{\Delta\beta}{2\tau} + g\right)\sin[\tau s/\sqrt{F}]\}\exp(-j\beta_M s) \tag{3-25}$$

$$A_b(s) = \{g\cos[\tau s/\sqrt{F}] - \sqrt{F}\left(ig\frac{\Delta\beta}{2\tau} + f\right)\sin[\tau s/\sqrt{F}]\}\exp(-j\beta_M s) \tag{3-26}$$

Here

$$f = A_m\Big|_{s=0}^{\psi=0},\quad g = A_p\Big|_{s=0}^{\psi=0},\quad F = \left[1+\left(\frac{\Delta\beta}{2\tau}\right)^2\right]^{-1},\quad \beta_M = (\beta_n+\beta_b)/2 \tag{3-27}$$

When $\Delta\beta << \tau$, the components discussed above are a quasi-linear polarized state, the polarity is rotational relative to the Serret-Frenet frame, and its rate of rotation approximates to $(-\tau)$.

From the preceding conclusion we can directly obtain from the state of polarity (SOP) P for the polarized light of the wave at the optic fiber terminal to be:

$$P=\frac{I_{max}-I_{min}}{I_{max}+I_{min}}=\cos\left\{\sin\left[-\frac{\Delta\beta}{\tau}\sqrt{F}\sin(\tau s/\sqrt{F})\left(\sin 2\phi\cos(\tau s/\sqrt{F})-\sqrt{F}\cos 2p\sin(s/\sqrt{F})\right)\right]\right\} \quad (3\text{-}28)$$

where I_{max} and I_{min} refer to maximum and minimum light intensities obtained from light output by an optic fiber terminal after passing through a variable direction analyzer. ϕ refers to the angle of incident polarity, so $\phi_1=\phi+\pi/2$, and obviously

$$P(\phi)=P(\phi_1) \quad (3\text{-}29)$$

This proves that P is related to the angle of incident polarity, and at a given location S, P is the periodic function of the angle of incident polarity, where the period is $\pi/2$. This is in complete agreement with the empirical curve (Figure 4a) produced in reference [4]. On the curve, $P_{min}\approx 0.975$, which shows that the elliptical polarity in these conditions is very close to linear polarity. This point is also explained by (3-28). Because when liquid core optic fiber winds around, $\Delta\beta$ comes primarily from the effects of elongation of the fiber core and waveguide geometry. Since the effects of these two things are both very small, we can know that although P can be somewhat less than 1 as S or ϕ changes, it is always nearly 1. For the general circular cross section optic fiber, the value of $\Delta\beta$ is always an increment. Therefore, fields of circular cross section optic fibers may be considered as quasi-linearly polarized. Because the demonstration of reference [4] used multi-mode optic fiber in a single-mode status, as the distance increased, higher order modes were excited, so their degree of polarized ellipsis became less.

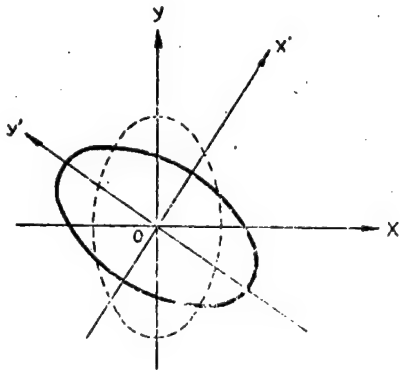


Figure 3. Fixed Coordinate System and a Rotating Coordinate System in Twisted Optic Fiber

IV. Conclusions

In this paper we have listed in the Tang coordinate system the Maxwell equation for a circular cross section cylindrical helical optic fiber, and have discovered that in this coordinate system scalar wave equations for field components are exactly the same as the scalar wave equation of purely curving

optic fiber. Consequently, in a similar manner we have used the perturbation method to derive a field's first-order distortion and the second-order correction of the propagation constant. We have proven theoretically that when using incident helical optic fiber with a linear state of polarity, the optic fiber fields maintain a quasi-linear state of polarity, where the polarity is relative to rotation in a Serret-Frenet frame at a rate that approaches $(-\tau)$ with the propagation distance S. At the same time, the state of polarity discussed above, that is, the degree of polarity elongation in a quasi-linear polarized field, changes with S, and is the periodic function of the angle of incident polarity, where the period is $\pi/2$. In substance this is similar to the twisting of linear double refraction optic fiber. These conclusions have been demonstrated by experimental results.

REFERENCES

[1] W. Sollfrey, "Wave Propagation on Helical Wires," J. Appl. Phys., 22, pp 905-910, 1951.

[2] R.S. Millman and G.D. Parker, "Elements of Differential Geometry," Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1977.

[3] C.H. Tang, "An Orthogonal Coordinate System for Curved Pipes," IEEE Trans. MTT-18, p 69, 1970.

[4] A. Papp and H. Harms, "Polarization Optics of Liquid-Core Optical Fibers," Appl. Opt., 16, pp 1315-1319, 1977.

[5] L. Lewin, D.C. Chang and E.F. Kuester, "Electromagnetic Waves and Curved Structures," Peregrinus Ltd., Southgate House, England, 1977.

[6] R.A. Sammut, C.D. Hussey, J.D. Love, and A.W. Snyder, "Modal Analysis of Polarization Effect in Weakly-Guiding Fibers," IEEE Proc., 128, Pt. H, pp 173-187, 1981.

[7] J. Sakai and T. Kimura, "Analytical Bending Loss Formula of Optical Fibers With Field Deformation," Radio Science, 17, pp 21-29, 1982.

[8] Fang Xisheng [2455 6932 3932] and Lin Zongqi [2651 1350 3823], "Perturbation Analysis of the Effects of Waveguide Geometry on Double Refraction When Single Mode Optic Fibers Are Twisted," YINGYONG KEXUE XUEBAO [JOURNAL OF APPLIED SCIENCE], 2, pp 345-352, 1984.

[9] [1129 6390], [5468 3069], and [3068 2625], "Polarized Wave Surface Rotation Characteristics of Single-Mode Optic Fiber," [in Japanese] JOURNAL OF COMMUNICATIONS, OQE-62, (1980-07).

[10] P. McIntyre and A.W. Snyder, "Light Propagation in Twisted Anisotropic Media: Application to Photoreceptors," J.O.S.A., 68, pp 149-157, 1978.

[11] M. Monerie and L. Jeunhomme, "Polarization Mode Coupling in Long Single-Mode Fibers," Opt. Quantum Electron., 12, pp 449-461, 1980.

12586/6091
CSO: 4008/1049

THEOREM PROPOSED REGARDING P-NP PROBLEM

Beijing KEXUE TONGBAO [SCIENCE BULLETIN] in Chinese Vol 30, No 10, May 85 pp 792-793

[Article by Wang Jie [3769 3381], Department of Computer Science, Zhongshan University, Guangzhou: "The Necessary and Sufficient Conditions When for B There Exists an A Such That $P^A = NP^B$"; paper received 10 February 1984]

[Text] Baker, et al., were the first to use relativization studies on the problem of P = ?NP, which obtained penetrating results. This paper discusses the necessary and sufficient conditions where for an arbitrary language B there is an existing language A that allows $P^A = NP^B$.

We used the "oracle" equipped Turing investigation machine of Cook as our computing model, detailed descriptions of which investigative machine may be seen in [2]. To not lose universality, we provided that the characters on the machine tape would be $\Gamma = \{0,1\}$. We used Γ^* to represent the closure of Γ. The set (language) discussed below is always a subset of Γ^*, indicated with an English capital letter, and the characters discussed are always elements of Γ^*, indicated with English lower case letters. We use $|x|$ to represent the length of character x, and $\overline{A}$ to indicate Γ^*-A. From references [1,2], we decided that investigating a character of length n could be deterministically complete with n steps.

We use ω to indicate the set of non-negative integers. Given that $\{P_i^{(X)}\}_{i\in\omega}$ and $\{NP_i^{(X)}\}_{i\in\omega}$, respectively, are an enumeration in polynomial time of a deterministic investigating machine and a non-deterministic one, $p_i(n) = i + n^i$ is the boundary in time for $P_i^{(X)}$ and $NP_i^{(X)}$, and n is the input length, $P_i^{(A)}$ and $NP_i^{(A)}$, respectively, represent $P_i^{(X)}$ and $NP_i^{(X)}$ of A by "oracle." Letting $P_i^A = \{x:P_i^{(A)} \text{ accepts } x\}$, $NP_i^A = \{x:NP_i^{(A)} \text{ accepts } x\}$; $P^A = \{P_i^A:i\in\omega\}$, $NP^A = \{NP_i^A:i\in\omega\}$. A more detailed explanation of these definitions can be found in reference [1].

We say that language B is Cook complete in NP^A if $B\in NP^A$ and $NP^A\subseteq P^B$. We know from reference [1] that $K(A) = \{\langle i,x,o^n\rangle$; a particular calculation of machine $NP_i^{(A)}$ that accepts x$\}$ within n steps is Cook complete within NP^A, and the $\langle i,x,o^n\rangle$ in it is a code for characters i,x,o^n.

Obviously, P^A is closed with regard to complementary operations.

Theorem. For any B, there exists an A such that $P^A = NP^B$ if and only if NP^B is closed with regard to complementary operations.

Proof. We first prove the following conclusions:

(I) For any A or B, if A is Cook complete in NP^B, then $P^A \subseteq NP^B$ if and only if NP^B is closed in regard to complementary operations.

Actually, if $P^A \subseteq NP^B$, then because A is Cook complete in NP^B, therefore $NP^B \subseteq P^A$, so $P^A = NP^B$. Consequently, we can know that NP^B is closed regarding complementary operations. Conversely, if NP^B is closed regarding complementary operations, then for $A \in NP^B$, there are $i, j \in \omega$ such that $A = NP_i^B$, $\overline{A} = NP_j^B$. For any $e \in \omega$, we create the investigation machine $Q_e^{(B)}$, which has a tape used to store $P_e^{(A)}$ as the element to be investigated in the calculation process, and with every pass of the investigation, this element is then immediately erased from the tape. For any input x, if $P_e^{(A)}$ has not entered the investigation state, then $Q_e^{(B)}$ simulates the calculation of $P_e^{(A)}$; otherwise, given that the character recorded on the special tape at this time is z, that $Q_e^{(B)}$ uses B is to z a determination of whether it belongs to A. Because $A = NP_i^B$, and $\overline{A} = NP_j^B$, therefore at this time let $Q_e^{(B)}$ non-determinately simulate $NP_i^{(B)}(z)$ and one in $NP_j^{(B)}(z)$. This way, the longest required time $p_i(|z|)p_j(|z|)$, we can then non-determinately decide whether $z \in A$. The next calculation step for $Q_e^{(B)}$ is to simulate the calculation after $P_e^{(A)}$ enters the true state (i.e., $z \in A$) or enters the false state (i.e., $z \in \overline{A}$), and the construction is complete.

Clearly, we can know from the construction that $P_e^{(A)}$ accepts x if and only if $Q_e^{(B)}$ accepts x. Because $P_e^{(A)}$ will enter the investigation state at most $p_e(n)$ times, and the length of the character investigated does not exceed $p_e(n)$, then the polynomial time for $Q_e^{(B)}$ is a finite $p_e(n)p_i(p_e(n))p_j(p_e(n))$, n is the input length. Therefore, $Q_e^B \in NP^B$ (Q_e^B indicates the language accepted by $Q_e^{(B)}$), that is, $P_e^A \in NP^B$. Consequently, $P^A \subseteq NP^B$. This proves conclusion (I).

We will now prove the conclusion of the theorem.

$\Leftarrow$ if NP^B is closed regarding complementary operations, then taking A = K(B), it is Cook complete within NP^B, and therefore $NP^B \subseteq P^A$, and also we can know from (I) that $P^A \subseteq NP^B$, so $P^A = NP^B$.

$\Rightarrow$ if there exists an A such that $P^A = NP^B$, then because P^A is closed to complementary operations, we therefore obtain NP^B being closed to complementary operations.

To sum up, the theorem is proved.

Corollary. There exists a recursive language A such that $P^A = NP$ if and only if NP = ω-NP.

Note: After revision of this paper, Dr Ker-I Ko of the Computer Science Department of Houston University told the author that he could also derive the conclusions of this paper from the work of C. Wrathall and L. Stockmeyer (see "Theoretical Computer Science," 3(1977), 23-33 and pp 1-22 of the same journal).

REFERENCES

[1] Baker, T., Gill, J., and Solovay, R., "Relativizations of the P=? NP Question," SIAM J. Comput., 4 (1975), 4: 431-442.

[2] Cook, S.A., "The Complexity of Theorem Procedures," Proceedings of the Third Annual ACM Symposium on Theory of Computing, 1971, 151-158.

12586/6091
CSO: 4008/1003

COUNTRY DEVELOPS NEW MEDICAL PLASTIC FOR GRAFTING

OW271126 Beijing XINHUA in English 1042 GMT 27 Feb 86

[Text] Beijing, 27 Feb (XINHUA)--Shanghai scientists have developed a new plastic used in grafting blood vessels and repairing heart damage, according to the newspaper HEALTH NEWS.

The new plastic, named polytetrafluoroethylene, is water-proof and resistant to heat, cold and corrosion. Though it has been widely used in industry, only one U.S. company produces medical polytetrafluoroethylene due to the complicated technology.

The Shanghai Plastic Institute and three famous hospitals started experimenting with the new plastic in 1979. The plastic has been used to graft blood vessels for 18 patients since 1981 with good results.

Since 1982, hospitals in Shanghai, Shenyang, Guangdong and Zhejiang have used the new plastic products to repair heart deformities in 60 children with congenital heart diseases.

Surgeons in those hospitals said the plastic products were convenient to use and there were no complications.

Experts at a recent appraisal meeting believe that the medical plastic products made in Shanghai approach the quality of similar products manufactured in the U.S.

/6662
CSO: 4010/1061

HIGH-POWER TUNABLE ALEXANDRITE LASER WITH GIANT PULSE OUTPUT, SHG

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6, No 5, May 86 pp 408-412

[Article by Zhang Bangxing [1728 1620 2502], Wu Lusheng [0702 6424 3932], Zhao Meirong [6392 2734 2837], and Zhang Haili [1728 3189 7787] of the Anhui Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, Hefei]

[Text] Abstract: The first tunable Q-switch alexandrite laser in China with high power and giant pulse output is reported in this paper. A tunable range of 730-790 nm, linewidth of 0.8 nm, pulse width of 30 ns and peak power of 10 MW have been achieved. Using a $LiIO_3$ crystal as a frequency doubler, the SHG tunable range of 368-393 nm and power conversion efficiency of 9 percent have been obtained.

I. Introduction

The alexandrite laser is a new type of tunable solid state laser developed in recent years. It has a wide tunable range, an ambient operating temperature and may be operated in the continuous mode or pulsed mode with Q-switching or mode locking[1,2]. It also has the advantage of a low threshold which decreases with increasing temperature. Its application prospects are good and it has received broad attention.

There have been some reports[3] on the characteristics of the alexandrite laser system. In this paper we investigate the optimization of the pumping parameters and the output coupling to achieve high-power giant pulse output. Using an $LiIO_3$ crystal for frequency doubling, a tunable range of 0.393-0.368 μm in the near ultraviolet was realized.

II. Optimization of the Laser System

In addition to a high-quality lasing medium, it is well known that the maximum output of a laser also requires a minimum cavity loss and a maximum pumping efficiency and output coupling.

1. Selection of Pumping Parameters

We concentrated on improving the rod dimension matching and the discharge waveform. The experiments used a 65 mm long 6.8 mm diameter alexandrite rod along the c-axis grown in our laboratory. To match the rod size, a strobe pump with a 60 mm electrode separation and an outer diameter of 9 mm was used. The color temperature of the lamp and the pumping efficiency were improved by using a low capacitance (200 μF) and high voltage method. By so doing the threshold was made eight times smaller than that of a high capacitance (2000 μF), low voltage, and long pulse length lamp (150 mm by 14 mm diameter).

To have more activated ions during pumping, the pure capacitive discharge circuit was changed into an LC network discharge circuit[1]. Figure 1 shows the xenon lamp discharge current waveform used in the experiments. The shape of the pulse was nearly rectangular, the half width was 200 μs, and the laser output was significantly improved with this circuit.

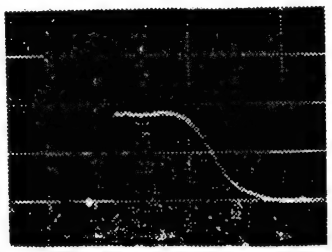


Figure 1. Discharging Waveform of the Xe Flash Lamp (100 μm/div)

At high temperatures alexandrite has good lasing characteristics. To take advantage of the high temperature properties, a repetition rate of 0.2-1 pps was used to achieve natural thermal equilibrium and better results.

2. Output Coupling

As is well known, alexandrite lasers usually have stable cavities. We have experimented with a single flat cavity and a single concave cavity (cavity length 40 cm) and showed that the single concave cavity had a lower threshold. Tests on concave cavities with radii of curvature of 500, 1000, and 3000 cm showed that although the threshold with decreasing radius at room temperature, it actually increased at high temperature, probably due to the effects of the thermal lens. In the present conditions r = 1000 cm worked the best.

To optimize the coupling, we experimented with four output plates with R = 50, 70, 80, and 97 percent and measured their pumping threshold, slope efficiency, and output energy. The results are listed in Table 1. For our experimental conditions, the best output coupling was obtained with R = 0.7-0.8 and the R = 0.8 output plate was used in the experiment.

Table 1. Output Parameters Under Various Output Reflectivity

parameter	R				notes
	50%	70%	80%	97%	
pumping threshold (J)	164	125	110	77	$C=200\,\mu F$
output energy (mJ)	100	430	440	107	$E_\lambda=196$ J
slope efficiency (%)	0.28	0.62	0.51	0.1	

Since the gain curve of alexandrite is bell-shaped, the output as a function of wavelength is also bell-shaped. However, we applied some special treatment on the output plate and drastically changed the output characteristics. The output was made to approach a rectangular shape (see Figure 2), which is very useful in applications.

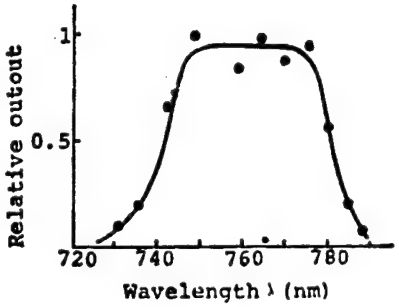


Figure 2. Tuning Curve

3. Tuning and Q-Switching

Commonly used tuning elements are prisms, gratings and double refraction filters. The linewidth is narrow in the grating tuning but the diffraction loss is great. The gratings are also susceptible to laser damage. The best configuration of a double refraction filter is a three-element structure, which has a narrow line and a relatively broad free spectrum zone. However, the disadvantage is that they are difficult to fabricate (especially plates thinner than 1 mm thick) and assemble. In our experiments tuning was accomplished by the combination of a ZF_3 prism and a 3.6 mm thick double refraction filter. This combination helped to narrow the broad line of a single prism and to broaden the narrow free spectrum region of a single double refraction filter. In order to minimize the loss in the cavity, all elements were placed at the Brewster angle.

The Q-switch used a KD*P electro-optic switch enclosed in a cell containing refractive index matching fluid and with antireflecting film coating on the window. For the spectral range studied, the transmissivity was greater than 95 percent.

III. Experimental Results

1. Steady State Output

The steady state pumping threshold was measured to be about 90 J when the cavity contained no insertion components and the device was operated at a repetition rate of 1 pps. For an input energy of 160 J, the maximum steady state output energy was close to 600 mJ and the slope was 6 percent. By inserting a ZF_3 prism in the cavity, the measured output wavelength was continuously tunable from 720 nm to 780 nm. The tuning range was 600 Å (as shown in Figure 2). By further inserting a double refraction filter, the output linewidth was suppressed down to ~8 Å and the tuning range remained unchanged. Figure 3 shows the linewidth of the laser under various conditions*.

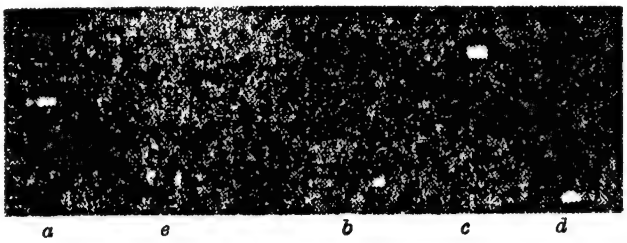


Figure 3. Photograph of Linewidth of the Alexandrite Laser
a--Free oscillation; b--K_9 prism; c--ZF_3 prism;
d--two ZF_3 prisms; e--combination of a ZF_3 prism
and birefringence filter

2. Dynamic Output

By inserting a Q-switch into the cavity, a Q-switched giant pulse output was obtained. The dynamic-static ratio was 1:2 and the pulse width was photographed to 30 ns using a 300 MHz oscilloscope. Figure 4 shows the waveform of the laser pulse and Table 2 lists the detailed parameters.

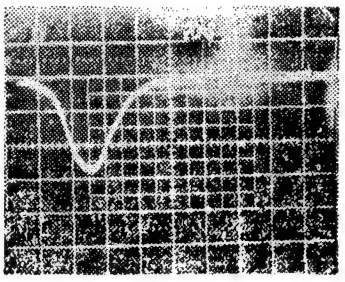


Figure 4. Photograph of the Laser Waveform

*Photograph was obtained by using a model W-100 1 meter grating diffractometer with a resolution of 8 Å/mm.

Table 2. Output Parameters of the Alexandrite Laser

	pumping threshold	output energy (mJ)	slope efficiency	tuning range	pulse width	laser linewidth
free oscillation	90J	~600	0.6%			~60 Å
tuning output	116J	~400	0.46%	~600 Å		8 Å
output uder Q-switching		~300			30 ns	
notes	$C=200\,\mu F$	$E_\lambda=196$ J		a prism	E-O Q-switch	

IV. Second Harmonics

In 1983 Barnes et al.[4] first reported frequency doubling of the alexandrite laser in a RDP crystal and obtained 8 percent conversion efficiency. Theory shows that the frequency doubling conversion efficiency is:

$$\eta \propto W_1 l^2 \frac{d^2}{n^3} \frac{\sin^2(\Delta kl/2)}{(\Delta kl/2)}, \tag{1}$$

Therefore, to improve the frequency doubling efficiency, a doubling crystal with a large nonlinear coefficient must be used--in addition to a high fundamental power. UV transparent $LiIO_3$ and XDP crystals are good for the frequency doubling of the alexandrite laser, since the latter had a greater (about 10 times) nonlinear coefficient, we chose to use a $LiIO_3$ crystal. The experimental results are as follows.

1. Tuning Curve

By placing the crystal on a high precision angular manipulator, we observed the frequency doubled output at different wavelengths. The results in Figure 5 show that the agreement between the experiment and the theory was good.

2. Matched Curves

Figure 6 shows the intensity of the frequency doubled light by firing the fundamental wavelength and varying the angle. The half width is about 4.8 mrad, greatly different from the theoretical value of 0.4 mrad. The discrepancy is caused mainly by the beam divergence of the fundamental. Our fundamental wave bandwidth at half maximum was about 4 Å, equivalent to 0.6 mrad in matching the tuning curve, and the divergence angle of the fundamental was 4 mrad. Therefore, the width of the angular tuning curve depends on the divergence angle.

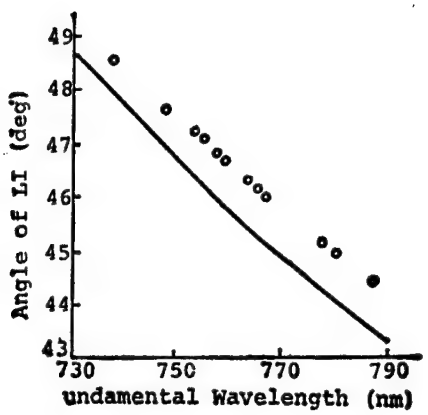


Figure 5. Match Angle of LI Crystal vs. Fundamental Wavelength

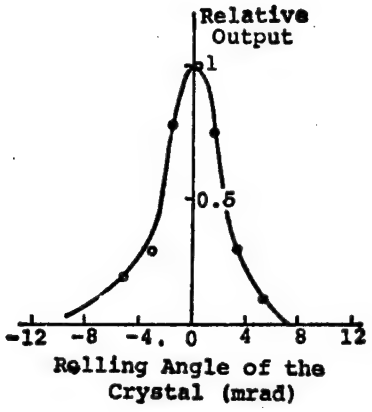


Figure 6. Angle-Matching Curve of the $LiIO_3$ Crystal

3. Conversion Efficiency

The conversion efficiency was measured at 760 nm. For a fundamental wave energy of 49 mJ, the measured UV output was 0.5 mJ. The fundamental was filtered by a model ZWB-1 glass filter. At 380 nm, the transmissivity was 15 percent, making the energy conversion efficiency 6 percent. The measured pulse width of the harmonic was 20 ns, and the deduced power conversion efficiency was 9 percent.

Due to the mass limitation of the rod, the device can only be operated in the multimode. This, of course, is also an important factor in the conversion efficiency. As the quality of the alexandrite crystals improves, so will the laser. It is entirely feasible to obtain a frequency doubling efficiency greater than 20 percent.

REFERENCES

1. Laser Focus (Buyers' Guide), 1984, 99.

2. Jeff Hecht, Laser & Applications, 1984, 3, No 9 (Sep), 77.

3. J.C. Walling, O.G. Peterson, et al., IEEE J. Quant. Electron., 1980, QE-16, No 12 (Dec), 1302.

4. N.P. Barnes, et al., IEEE J. Quant. Electron., 1983, QE-19, No 9 (Sep), 1437.

9698/6091
CSO: 4008/78

BRIEFS

ROBOT DEVELOPMENT--Beijing, 30 May (XINHUA)--There are nearly 1,000 Chinese experts now specializing in developing robots, according to the latest issue of BANYUE TAN [SEMIMONTHLY TALKS], No 10, pp 44-45, a popular magazine of current affairs. China has so far produced 100 robots over the past decade, including 1 which can do arc welding. The robot, named "Hua Yu No 1", is 1.6 meters high and weighs 750 kgs. With five movable joints, including the "arms", "wrists", and "waist", it is able to "hear", "touch", and "see", and understand two dozen Chinese words. The magazine quoted robot technology experts as saying that the major technical norms of this robot is up to international standards. "Hua Yu No 1" was developed in northeast China, by the Harbin Institute of Technology and State-Xien Fenghua [7364 5478] Plant. It is the first robot built by China for industrial use, the magazine said. [Text] [Beijing XINHUA in English 1159 GMT 30 May 86 OW] /6662

COMPUTER-CONTROLLED MINING MACHINES--Changsha, 7 Jun (XINHUA)--Chinese and American experts praised the quality of a new batch of 16- and 23-cu m dredging machines at an appraisal meeting here. The dredgers, designed for use in mining operations, were produced in Hunan Province with American technology. The computer-controlled dredgers were manufactured by the Xiangtan Electric Machinery Plant. Since it signed contracts with the American Harnischfeger Company for technology import and cooperative production, the plant has been busy training technicians and setting up strict examination regulations to ensure product quality. As a result, the 40 pieces of computerized equipment all meet the current international quality standards, according to an American expert. [Text] [Beijing XINHUA in English 0605 GMT 7 Jun 86 OW] /6662

TV COMPONENTS MEET INTERNATIONAL STANDARD--Shanghai, 16 Jun (XINHUA)--A delay-line for use in color TV sets, developed by a Shanghai factory, is up to the international standard, according to German experts. Experts from Loewe Opta GmbH, one of the three major color TV producers in Federal Germany, wrote a letter to the director of the Shanghai Radio Plant No 28 recently, which said that the plant had shipped more than a million pieces of this component, which ensures clear pictures. The technical performance of the product is up the international standard and the reject rate is "extremely low." The component is the first Chinese electronic product to enter the very competitive European market. The Shanghai plant succeeded in developing the component for the German company in 1982. The factory has doubled its supplies of the component. [Text] [Beijing XINHUA in English 0040 GMT 16 Jun 86 OW] /6662

VOICE-RESPONSIVE COMPUTER WRITES CHARACTERS--Beijing, 5 Jul (XINHUA)--China has developed its first computer which responds to human voices, the overseas edition of today's PEOPLE'S DAILY reported. Speaking Chinese into a microphone, the operator gets the characters on the screen one by one within 0.5 second intervals on average. The computer was invented by the Harbin Polytechnical College. It has 98 percent accuracy, the paper said. It is more efficient that computers connected to keyboards or electronic pens, and is much cheaper than similar foreign products. [Text] [Beijing XINHUA in English 1450 GMT 5 Jul 86 OW] /6662

WEATHER RADAR, SEISMIC INSTRUMENT--Beijing, 29 Jul (XINHUA)--Today's economic news in brief: Weather radar: A sophiscated radar has been installed atop Mount Huangshan in Anhui Province to help forecast weather over East China, one of the best developed areas in China. Experts have said that this is the first facility up to the latest international standards ever designed and made by China. The radar on the Guangming peak 1,841 meters above sea level can forecast typhoon, torrential rain and other disastrous weather. Xinjiang exports rare metals: Xinjiang has exported 31 million U.S. dollars worth of lithium, beryllium, tantalum and niobium and other rare metals since 1981. Covering one sixth of China's land mass, the region has 118 types of minerals, 50 percent of the total known in the world. New rock stress instrument helps quake forecasts: China has developed an instrument for recording rock stress, which may help forecast earthquakes and cave-ins of mines, reservoirs and tunnels. Trial use over the past two years proves that it can record abnormal seismic changes for an earthquake of up to six-magnitude a few hours to one month in advance, according to experts attending a recent appraisal meeting for the instrument. Developed by a research institute under the Ministry of Nuclear Industry, the instrument won a prize at an international exhibition of inventions and new techniques in Geneva in April this year. [Text] [Beijing XINHUA in English 1347 GMT 29 Jul 86 OW] /6662

QAIDAM PARABOLIC ANTENNA--Beijing, 26 Jul (XINHUA)--China's biggest parabolic antenna on a radio zenith telescope has been installed in the east of the Qaidam Basin in northwest China. The antenna is 13.7 meters in diameter and 7 tons in weight. Its horizontal error is less than 1 millimeter. Before this new project, China's largest parabolic antenna for astronomy was only 2.5 meters in diamter. [Text] [Beijing XINHUA in English 1352 GMT 26 Jun 86 OW] /6662

CHINESE-LANGUAGE COMPUTER--Beijing, 28 Apr (XINHUA)--A Chinese-language JH microcomputer system, the largest such system in the Chinese language in China, passed technical appraisal in Beijing recently. Experts have determined that the JH system equals the advanced level of similar foreign products of the 1980's in information processing. The successful development of this computer system will certainly play a great role in boosting China's economic development and defense modernization. Currently, nearly 1,000 JH systems are being used by various departments concerned in China. [Summary] [Beijing XINHUA Domestic Service in Chinese 1204 GMT 28 Apr 86 OW] /9738

CHINESE-CHARACTER COMPUTER--Beijing, 7 May 86 (XINHUA)--A popular type of Chinese-character computer, developed in China, passed the evaluation of the Chinese Academy of Sciences on 6 May. The computer enables the use of Chinese characters for input and display, and enables reporters and writers

to directly use it for drafting and teachers to use it to teach mathematics, physics, chemistry, and other subjects. The computer has gone into production in Chengde City, Hebei province. [Summary] [Beijing XINHUA Domestic Service in Chinese 1333 GMT 7 May 86 OW] /9738

MULTIPURPOSE COMPUTER TERMINAL--A multipurpose computer terminal, code-named CT 110, passed a technical test in Beijing on 24 June. In addition to its input capacity for Chinese characters, the machine can enter other characters according to the forms of the strokes. Moreover, it is capable of forming words, storing phrases, and providing instructions. [Summary] [Beijing XINHUA Domestic Service in Chinese 1049 GMT 24 Jun 86 OW] /9738

CSO: 4008/1107

ENVIRONMENTAL QUALITY

REVIEW OF PROGRESS IN ENVIRONMENTAL PROTECTION

Beijing HUANJING BAOHU [ENVIRONMENTAL PROTECTION] in Chinese No 3, 25 Mar 86; No 4, 25 Apr 86

[Article by Cheng Zhenhua [4453 2182 5478], Ministry of Urban and Rural Construction and Environmental Protection, under the rubric "This Issue's Special Article": "Progress and Experience in Environmental Protection in China During the Sixth 5-Year Plan"]

[25 Mar 86 pp 2-3, 18]

[Text] The period of the Sixth 5-Year Plan was the best period for environmental protection in China since its inception and development as a cause. Through those 5 years of efforts China made environmental protection a fundamental national policy, achieved record-breaking progress, and accumulated a great wealth of experience.

To summarize, China made advances in the following 10 areas of environmental protection during the Sixth 5-Year Plan:

1. Environmental consciousness was notably improved throughout the nation. Through 5 years of environmental propaganda and education, environmental protection has become the major order of the day for the party and the state. It has become a strategy upon which to found and administer the nation, and it has become a people's cause. Now a favorable wind of "honor for environmental protection and disgrace for environmental destruction" is beginning to blow throughout society. To China, a nation of vast territory, teeming population, and still relatively backward economy and culture, this is indeed extraordinary progress.

2. Environmental protection mechanisms have been augmented. In the restructuring of state organs in 1982 the Ministry of Urban and Rural Construction and Environmental Protection was formally established and the temporary Environmental Protection Administrative Organization at the primary state level was terminated. On 8 April 1984 a State Council Environmental Protection Commission made up of officials from each State Council department was established under the direction of Vice Premier Li Peng. It is responsible for studying and approving all relevant environmental protection

policies nationwide, proposing planning needs, and guiding, organizing, and coordinating environmental protection work throughout the nation. At the same time, subsequent to State Council approval the State Environmental Protection Bureau was established to enhance leadership in nationwide environmental protection work, act as the administrative body for the State Council Environmental Protection Commission, and exercise environmental protection planning, coordination, supervision, and guidance functions. From the state on down to the provinces, prefectures, municipalities, and nearly 800 counties, various concerned state and local industrial and agricultural departments and some medium-sized and large enterprises have now established corresponding environmental protection organizations. We have formed a nationwide environmental protection contingent possessed of certain political and professional qualities. According to 1984 year-end statistics, there are 33,000 people in the ranks of environmental protection work in China, of which 57 percent are scientific and technical personnel and more than 4,300 are mid- and high-level scientific and technical personnel.

3. Results of comprehensive renovations in the urban environment are striking. During the Sixth 5-Year Plan, in the wake of an intense expansion of urban economic restructuring, city governments and mayors attached great importance to urban environmental protection. Under direct mayoral leadership individual controls on urban environmental pollution gave way to comprehensive repairs, considerably improving the state of the urban environment. In water pollution control, in 1985 medium-sized and large cities across the nation brought 99 rivers (or river sections) and lakes under control, and 10 medium-sized and large cities built sewage treatment plants. Water quality has taken an obvious turn for the better in the controlled rivers and lakes: in some the fish and shrimp have recovered and are proliferating, and some have attained national 2nd- or 3rd-class surface-water standards. As for air pollution control, in 1985 90 medium-sized and large cities nationwide established a total 148 soot control regions. Shanghai Municipality began in 1982 to institute work on soot control test sites, and by 1985 the city proper had achieved a complete absence of black smoke. In the area of urban noise control, based on statistics from 90-plus medium-sized and large cities, noise control has been put into effect on 174 streets and residential districts. Many cities have promulgated and implemented traffic noise control laws and regulations, and within the control districts traffic noise has generally declined 2-7 decibels. In addition, in many cities greening and beautifying city appearances, living environments, and working environments have been made major components of comprehensive renovations in the urban environment. Landscaped areas in the cities have been enlarged, changing the appearance of the urban environment in a major way.

4. New progress has been made in industrial pollution control. In China, environmental pollution is caused primarily by industrial pollution. During the Sixth 5-Year Plan many industrial enterprises nationwide emulated the example that Anshan Iron and Steel Complex set in environmental protection: they integrated technological reform with industrial pollution control, effectively alleviating environmental pollution and achieving controls on a number of serious pollution sources. In 1979 the state announced 167 time-limited projects to bring serious polluters under control, and the provinces, autonomous regions, and state-administered municipalities announced similar

projects. All of these have been essentially accomplished. In the 5 years from 1980 through 1984 over 120,000 such control projects were organized, and nearly 9,000 of them have been completed and put into operation. Our wastewater treatment capacity is increasing by 22 million tons per day and our waste-gas processing capacity is rising by 420 million standard stere per hour. At the end of 1984 the national industrial wastewater treatment ratio was 22 percent, and 37 percent of all wastewater discharged met specifications; the waste residue processing ratio was 28.1 percent, and 26.3 percent of all waste residue was used for multiple purposes. The past several years of comprehensive control in industrial pollution has brought China some measure of control over industrial pollution and reduced the expensive discharge of "the three wastes" by about one-third. Not only that, it has also improved the multipurpose utilization ratio for natural and energy resources and achieved obvious economic results. Based on 1984 statistics, products gained through multipurpose utilization of "the three wastes" are worth 2.05 billion yuan and bring in profits of 500 million yuan.

5. We are getting better year by year at executing "the three simultaneous efforts" in capital construction projects. In 1976 only 18 percent of medium-sized and large capital construction projects fulfilled or basically fulfilled stipulations to simultaneously plan, construct, and operate principal projects in conjunction with environmental protection facilities. During the Fifth 5-Year Plan this ratio was less than 50 percent. During the Sixth 5-Year Plan the proportion of capital construction projects implementing the "three simultaneous efforts" rose year after year, until in 1984 the ratio stood at about 75 percent. In 1985, based on statistics from 15 provinces, autonomous regions, and state-administered municipalities, 93.8 percent of new construction projects operated through the "environmental impact statement" examination and approval system, and "the three simultaneous efforts" were implemented in 85 percent of all new medium- and large-scale construction, expansions, and remodeling. Many regions also began to institute systems to approve "environmental impact statement forms" and to enact the "three simultaneous efforts" in township and neighborbood enterprise construction projects. Wuxi, where township enterprises are most developed, maintains tight control over the examination and approval of township enterprise construction. Unapproved construction projects that produce serious pollution comprise 10 to 20 percent of the total number of township enterprises. Thus, new pollution sources have been effectively brought under control.

6. Protecting the natural environment is being accorded great importance. During the Sixth 5-Year Plan China has accelerated the pace of natural conservation. Up to the end of 1984 China had established 262 nature sanctuaries of various kinds with a total area of 156,000 square kilometers, or over 1.62 percent of the total land area of China. The state has adopted appropriate protective measures for 354 kinds of rare plants and 50 kinds of rare animals. In addition ecological farming has developed rapidly in China, and as of now 209 ecological farming test villages (or townships) have been set up nationwide to provide us with experience in exploring avenues for conserving the ecological agricultural environment. Guangdong's Shunde County, Zhejiang's Jiashan County, Guangdong's Dongwan County, Tangshan in Hebei, and Wuxi in Jiangsu have all performed brilliantly in controlling pollution from township enterprises and in conserving the ecology of the

agricultural environment. They have taken care to organize industrial composition in a reasonable fashion and ensure that nonpolluting and nonserious polluting enterprises comprise about 90 percent of township enterprises.

7. Environmental protection industries are beginning to take shape. During the Sixth 5-Year Plan environmental protection industries producing environmental protection equipment and instruments began to form and expand rapidly. Based on partial statistics, as of the end of 1984 there were 1,100-plus enterprises in the environmental protection industry, over 250,000 workers and staff, more than 2,000 kinds of products, and an annual output value of 1.5 billion yuan. Major products include specialized instruments and equipment for use in environmental monitoring, facilities for purifying and multipurpose utilization of "the three wastes," equipment for noise and vibration control, new techniques and equipment for resource and energy conservation and pollution control, and so forth. More than 150 of these products have been awarded major state, provincial, municipal, or industry scientific achievement awards, and some of them have been exported to over 30 Middle Eastern and Southeast Asian Countries.

8. There have been new breakthroughs in environmental science research and environmental monitoring. By the end of 1984, 69 provincial-level and municipal-level environmental science institutes had been established in 27 provinces, autonomous regions, and state-administered municipalities, as well as in some industrially concentrated cities across the nation; the Chinese Academy of Sciences, the Chinese Academy of Social Sciences, and some institutions of higher learning had established a total of 79 environmental science institutes and offices; and there were over 8,000 specialized personnel engaged in environmental science research. In 1985 the state reviewed and appraised scientific environmental protection research problems addressed during the Sixth 5-Year Plan and conferred Scientific Progress Awards on 18 achievements. In 1985 the state's key scientific and technological projects for the Sixth 5-Year Plan, those in "Technological Research on Environmental Protection and Pollution Control," were completed on schedule. Many achievements have reached a relatively high level and some have been adopted by government departments or planning departments.

By the end of 1984 there were 1,144 environmental monitoring stations and a contingent of over 17,000 people in environmental monitoring in China. In 1985 39 municipal-level and 95 county-level monitoring stations were completed or newly constructed. Automatic methods were significantly improved at all municipal-level monitoring stations. The multi-function automatic monitoring system in Shanghai and the automatic atmospheric monitoring systems in 15 other cities, including Luoyang, Hangzhou, Shenyang, and Chengdu, are completely operational. Now China has tentatively formed a nationwide atmospheric monitoring network focussed on medium-sized and large cities and a water quality monitoring system focussed on the nation's river network and maritime space.

9. Environmental laws, regulations, and standards have been further developed. During the Sixth 5-Year Plan environmental legislation received significant party and state attention. In 1982 the Standing Committee of the

National People's Congress promulgated the "Marine Environmental Protection Law of the People's Republic of China," and in 1984 it further promulgated the "Water Pollution Control Law of the People's Republic of China." In addition, an "Atmospheric Pollution Control Law," an "Urban Noise Control Law," a "Wild Animal Protection Law," and "Nature Sanctuary Regulations" are now being drafted or submitted for approval. During the Sixth 5-Year Plan the State Council annually issued relevant documents on environmental protection and guided the principles and policies of national environmental protection work. Simultaneously China made major headway in work on environmental standards, and as of now has issued 61 environmental standards of various kinds.

10. We have had outstanding success with environmental protection propaganda and education. During the Sixth 5-Year Plan the CHINA ENVIRONMENTAL NEWS and the China Environmental Publishing House were established. The CHINA ENVIRONMENTAL NEWS has published 500,000 pages and played a positive role in improving environmental consiousness across the nation. Local environmental protection newspapers and periodicals have also proliferated: according to partial statistics there are more than 150 of them. Shanghai Municipality and Tianjin Municipality have also established environmental propaganda and education centers and adopted various forms for initiating propaganda and education work.

During the Sixth 5-Year Plan environmental protection educational facilities also expanded rapidly. As of the end of 1985 there were 44 institutions of higher education that had established specialties in environmental protection and 34 that had undertaken to train graduate students for the Master's degree. There were 370-plus Master's students, more than 4,500 undergraduates, and 1,700 other college and university students. Suzhou College of Urban and Rural Construction and Environmental Protection is already tentatively complete, and in 1985 it recruited its first class of undergraduates in environmental planning and management. Qinhuangdao Cadre School of Environmental Management has for the most part completed capital construction and will begin to recruit students in 1986.

[25 Apr 86 pp 2-3, 30]

[Text] China made gratifying progress in environmental protection during the Sixth 5-Year Plan and laid a firm foundation for completing, by the end of this century, the strategic environmental protection goals and missions suggested by the 2nd National Conference on Environmental Protection. We also gained valuable experience for initiating new phases in environmental protection work. What did China learn from environmental protection work during the Sixth 5-Year Plan? I feel the following two features are the most important:

I. We Must Realistically Bring Environmental Protection Work Into the Orbit of the Four Modernizations

During the Sixth 5-Year Plan a major transformation was wrought in the professional guiding ideology behind environmental protection work in China. This transformation calls for environmental protection work to serve and

submit to the overall mission and general goals of the party, to be tackled in combination with economic tasks, and to advance attainment of the magnificent socialist goal of the four modernizations. From a macroeconomic perspective, this has brought order to the dialectical relationship between environmental protection and economic development and essentially placed environmental protection in its correct status within the cause of modernization. It has allowed environmental protection the scope to display its capabilities and new vitality within the vast field of the four modernizations. Based on this professional guiding ideology China's environmental protection workers have proceeded from our own national conditions and strengths to make bold developments and changes. They have established a strategic environmental protection plan for China, determined major environmental protection policies, and blazed a Chinese path through a series of specific environmental protection tasks.

Based on the state's overall policy of relying primarily on focussed, gradual technological reform in established enterprises to develop the national economy, in the latter half of 1981 we reviewed what Anshan Iron and Steel Complex has experienced in "regeneration through self-reliance, multipurpose use of natural and energy resources, and control over 'the three wastes.'" We took multipurpose usage and prudent exploitation of natural and energy resources to be our point of departure in establishing China's industrial pollution control strategy, and we followed a path that integrated technological reform with industrial pollution control. On this foundation, in 1983 the State Council promulgated its "Provisions for Integrating Technological Reform With Industrial Pollution Control." In the first half of 1983, in view of certain environmental problems that appeared in the course of rural economic reform, we also analyzed a number of typical examples of coordinated development between rural township enterprises and ecological environmental protection in Shunde County Guangdong. We proposed certain provisions to control township enterprise pollution and protect the ecological farm environment while vitalizing the rural economy. These constitute "Several Provisions for Enhancing Environmental Management in Township and Neighborhood Enterprises," promulgated in 1984. In accordance with new circumstances that emerged out of our open door policy, and based on investigative research, beginning at the end of 1984 the Symposium on Environmental Legislation In Open Economic Zones was convened in Xiamen Fujian. There we formulated "Provisions for Enhancing Environmental Management in Special Economic Zones, Open Coastal Cities, and Open Coastal Economic Zones" (being drafted). In June 1985 these provisions were passed in principle at the fourth conference of the State Council Environmental Protection Commission, chaired by Vice Premier Li Peng. After revision, examination, and approval, they can be issued and put into effect. As for wielding economic means to carry out environmental management, at the 1984 annual meeting we coordinated with relevant departments of the State Planning Commission and the Ministry of Finance and issued provisions on environmental protection funding channels. We put such funding channels into effect in eight areas and chose a path not solely dependent upon state money, funds divided into parts, or funds raised through many channels. These provisions embody the principle that "Whoever pollutes must bring the problem under control," and they conform to China's national conditions and strengths. They also hold general relevance for professional endeavors in other fields. In

1985, in the light of new experiences in comprehensive renovations to some urban environments while restructuring the urban economic system, the fifth conference of the State Council Environmental Protection Commission was convened in Luoyang, attended by the mayors of 70 cities. The special concentration was on urban environmental protection work, and the conference discussed concrete provisions for urban environmental management.

The point that needs special attention is that at the Second National Conference on Environmental Protection, convened at the beginning of 1984, leading comrades at the State Council explicitly indicated that environmental protection is a fundamental national policy in China. They also posed strategic objectives, priorities, steps, and measures for environmental protection in China up to the end of this century and formulated a strategic policy of "three simultaneous steps": simultaneous planning, implementation, and development of economic, urban/rural, and environmental construction in order to bring about integration of economic, social, and environmental benefits. These steps essentially stipulate the professional guiding ideology behind environmental protection work in China and assure that this work will advance along the correct path. In addition, in the spirit of the policy of "three simultaneous steps," officials formulated for China an Environmental Protection Program for the year 2000 and an Environmental Protection Plan for the Seventh 5-Year Plan. They issued a policy on technology to control atmospheric pollution from coal combustion, and, with the approval of the Standing Committee of the National People's Congress, they promulgated the Marine Environmental Protection Law and the Water Pollution Control Law. These both concretely reflect the professional guiding ideology that environmental protection must serve the four modernizations. After they are put into effect we will be able to achieve our goal of coordinated development in environmental protection and economic construction.

II. Environmental Protection Work Must "Comprehend Realities and Produce Practical Results"

At the Second National Conference on Environmental Protection Vice Premier Li Peng proposed as a major target that environmental protection work must "comprehend realities and produce practical results." In the past couple of years or so the spirit of this aim has progressively become the criterion of action at all levels of leadership and among the mass of environmental protection workers. In addition, in many places it has formed a system, spurring major changes in the style and method of environmental protection work in China and bringing that work up to date throughout the country. Since the State Council Environmental Protection Commission was established in May 1984 one conference has been held each quarter, chaired by Vice Premier Li Peng, to study and resolve a number of significant practical problems. Prodded by leading comrades at the State Council who personally take charge of environmental protection work, many city mayors themselves have set to work to take control and institute comprehensive renovations on environmental problems that most concern the masses and that most urgently need to be resolved. According to my understanding, chief officials of more than 150 cities nationwide have actively elected to take charge of environmental protection work. They have indulged in no idle talk, but set about practical tasks. Based on actual local conditions, they have taken charge of priorities and

mobilized the masses to tackle wastewater, soot, noise, and urban refuse, and have rapidly solved a significant number of "old and difficult" environmental pollution problems. Within a short period of a year and a half, the number of cities in which environmental conditions are notably improved, such as Luoyang, Harbin, Hangzhou, Beijing, Tianjin, and Hefei, has surged. In the past, cadres in environmental protection departments seeking to report to government leaders could not get in to do so; now the leadership takes the initiative to ask for reports from environmental protection departments. Under the influence of this realistic approach the broad masses are able to see and feel the achievements we have made; this not only enhances confidence in environmental protection, it also improves national consciousness. For example, in order to protect water quality in canals leading to the Luan He entering Tianjin, Hebei has adopted practical measures to bring all 44 polluting enterprises along the banks into a time-limited control program. Chengde Prefecture on its own raised 1.57 million yuan in 1985 for use in controlling pollution, bringing its annual sewage treatment capacity up to 6.56 million tons and raising its utilization rate in the hydrologic cycle to 28 percent. Forty-six percent of the wastewater entering the Luan He River System meets state discharge standards. Zunhua County has already completed controls on pollution sources along canals to the Luan He entering Tianjin, and 100 percent of wastewater meets discharge standards. In order to restore its "spring city" image, the city government of Jinan made a resolution adopting measures to broaden sources of income, reduce expenditures, plan water usage, and conserve water resources. They have saved 5.5 million tons of water per year and raised their water reutilization rate to 50 percent. They have planted 132,000 mu of forest to conserve water resources, raising the water table to its highest level in recent years and reducing the amount of time the springs are dry each year from 8 months to something over 2 months.

Experience verifies that in environmental protection work there are three advantages to encouraging a solid work style that "comprehends realities and produces practical results": First, it suits public opinion, enjoys popular support, allows the masses to see and feel results, achieves practical benefits, and enhances the people's confidence in controlling environmental pollution. Second, it can augment mass supervision of the leadership, control the bureaucratism and generality of work in government organs, establish a favorable style whereby leading cadres resolve practical problems, and promote an essential improvement in party style. Third, it can bring the leadership to understand the severity of environmental pollution and enhance the sense of urgency for accomplishing environmental protection tasks. If we resolve a few prominent environmental problems each year, work little by little until it adds up significantly, and persist year after year, we can rather quickly improve the appearance of the environment in China.

In summary, the current state of environmental protection work in China is gratifying. Of course, we must keep a clear head under these circumstances: we must realize that from an overall perspective the realities of environmental protection tasks confronting China are still very grim and the responsibility is very heavy. These realities are that, first, environmental pollution and ecological destruction are still relatively severe. We absolutely cannot treat this situation lightly or lower our guard; we must

handle it conscientiously. Second, China is a developing nation, and the level of economic and scientific technological development is still relatively backward. For some time to come the state will be unable to set aside adequate funds and technical equipment to control environmental pollution and ecological destruction. Proceeding from these two national characteristics, we must work long and hard to realize our end-of-century environmental protection goals and achieve a fundamental improvement in the state of China's environment while also accomplishing the magnificent goal of socialist modernization. As for concrete steps, we can proceed through two stages: In the first stage, within the Seventh 5-Year Plan--that is prior to 1990--we must resolve a significant number of relatively simple and inexpensive environmental problems by enhancing environmental management, implementing proper technical policies, and other means. In the second stage, within the 10 years from 1990 to 2000, we must resolve the more difficult and expensive environmental problems primarily by allocating suitable technical equipment for environmental protection and tackling key technical problems, as well as through hard scientific and technical measures. Of course, these two steps are not completely separate from each other; they are only differentiated from macroeconomic and strategic standpoints and can be completely interchangeable. To summarize, if we are to resolve China's environmental problems, we must rely first on policy, second on technology, and third on management: these are the three essential measures that suit national environmental conditions in China.

12510
CSO:4008/1071

ENVIRONMENTAL QUALITY

SHANDONG'S LIANG BUTING ON ENVIRONMENTAL PROTECTION

SK300859 Jinan Shandong Provincial Service in Mandarin 2300 GMT 29 Apr 86

[Text] At a provincial urban environmental protection conference held by the provincial government, Liang Buting, secretary of the provincial CPC committee, stressed: Environmental protection is the epitome of the material and spiritual civilizations. CPC committees and governments at all levels should attach importance to environmental protection. For the benefit of our generation and generations to come, we should be greatly determined to promote Shandong's environmental protection.

The conference was held in Jian from 27 to 29 April. Yang Xingfu, Standing Committee member of the provincial CPC committee and director of its enterprise political work department, gave a speech at the conference. Song Yimin, adviser to the provincial government and chairman of the provincial environmental protection committee, delivered a work report.

The conference set forth eight tasks for the province to accomplish within the near future.

1. While developing the 4 lakes in the southern part of the province, it should eliminate the 14 major pollution sources in 3 years so that the quality of the 90,000-mu polluted water areas will reach the state third-grade standard for surface water.

2. It should treat the pollution of the Xiaoqing He in a comprehensive manner, and eliminate the 30 major pollution sources in Jinan, Zibo, and other cities within the near future.

3. It should turn a group of districts and neighborhoods throughout the province into ones free of dark smoke. Within this year, the smoke and dust discharge of 85 percent of burning equipment in old Jinan proper, the (Nanqu) district of Qingdao City, the (Zhangdian) district of Zibo, and the coal dust control area to the east of the (Haiwan) Road of Yantai should reach the state standard. At least one or two streets in other cities should become free of dark smoke.

4. It should pay attention to the research, production, and application of [words indistinct] coal in Jinan and two other key polluted cities.

5. It should complete the investigations on the industrial pollution sources of the province, start the investigations on the environments of township enterprises, give priority to the analysis of the development of trades which cause serious pollution, establish files on industrial pollution sources, and formulate measures for township enterprises to manage their environments.

6. It should designate a number of neighborhoods and districts which should reach certain targets for controlling noise pollution caused by traffic. Major neighborhoods of key cities, main lines of communication in cities proper, and densely populated areas should reach the state standard for traffic noise. The noise produced by car horns in 19 cities of the province should be brought under the limit stipulated by the province.

7. Key cities should build garbage treatment plants.

8. Based on the existing [words indistinct] foundation, Jinan and Qingdao should establish an industrial production capacity in the comprehensive utilization of the residues of [words indistinct].

/6662
CSO: 4008/1110

GUANGDONG URGES SOLVING POLLUTION PROBLEMS

HK020840 Guangzhou Guangdong Provincial Service in Mandarin 0900 GMT 30 May 86

[Text] This morning, the Guangdong Provincial Environmental Protection Bureau and Guangzhou City Environmental Protection Office held a joint news briefing to publicize the environmental quality status in Guangdong Province and Guangzhou City in 1985.

The environmental quality of our province, including Guangzhou City last year was, on the whole, continuously under control and the atmospheric and water quality of the main rivers was basically [passage indistinct] maintained at the 1984 level.

However, organic pollution of water quality in the lower reaches of the rivers at some cities has deteriorated and acid precipitation in cities has not been effectively controlled. Of these cities, the degree of acid precipitation in Guangzhou City is especially serious. Due to traffic jams, the problems from exhaust gases and noise pollution caused by motor vehicles in large cities whose transport facilities have developed, including Guangzhou City, have become more and more conspicuous.

In improving the water quality of rivers, the provincial and city departments concerned are taking measures to solve the problems, including speeding up the construction of Guangzhou City (Dadansha) Polluted Water Disposal Plant. Some of this plant's facilities can be completed and made available to users this year. The importing of techniques for the suburban (Baishahe) and (Lide) Exrement and Urine Disposal Plants is being stepped up and these plants can be completed by the end of this year.

In controlling black smoke and noise, experts and officials of the provincial and city environmental protection departments have proposed that the industrial enterprises in the cities and township industrial enterprises should demolish chimneys which send out black smoke. Where conditions permit, the cities must popularize Guangzhou City's method of building smoke-free streets. In addition, Guangzhou City has formulated regulations on the prohibition of horn sounding and on the demolition of outdoor generating sets in 30 roads, including Zhongshan Road and Beijing Road. These regulations will be put into effect from 1 June. Offenders will be punished.

/6662
CSO: 4008/1110

ANTIPOLLUTION WORK IN SHANGHAI OUTLINED

OW060548 Shanghai City Service in Mandarin 0000 GMT 5 Jun 86

[Text] On the eve of 5 June, designated by the United Nations, World Environmental Day, Rui Xingwen, secretary of the Shanghai Municipal CPC Committee, made a televised speech to the people throughout the municipality, entitled "Strive To Build Shanghai Into a Clean, Beautiful, and Civilized City."

In his speech Rui Xingwen said: The environmental question is now one of the major issues confronting countries throughout the world, including China. During the past few years Shanghai has done much work on environmental protection. In the proposal for the Seventh 5-Year Plan and in the plan itself, adopted at the Fifth Municipal CPC Congress and the Fifth Session of the Eighth Municipal People's Congress respectively, construction of municipal facilities and control of environmental pollution are listed as one of the major tasks for the days to come. In this connection, we plan to emphasize the following important tasks:

1. We should solve the problem of the quality of drinking water for the 10 million people in Shanghai. It is expected that around 1 July next year our people will have much cleaner tap water to drink than they have now, and that some time during the Seventh 5-Year Plan, they will be able to have drinking water of the second grade in quality.

2. We should control air pollution and eliminate acid rain. We plan to do away with practically all coal-burning stoves before the year 1990.

3. We should solve the problem of contamination of Suzhou He and Huangpu Jiang.

4. We should lessen the extent of environmental pollution by developing new industries and transforming old ones.

Rui Xingwen added: Economic development and pollution control are both necessary. The two are dialectical in nature. In the past environmental pollution was attributed to economic development. That was inappropriate. We should say that only when we have increased our economic strength are we capable of preventing and controlling pollution.

Concluding his speech, Rui Xingwen urged all departments and units to coordinate with each other and make concerted efforts to achieve the goal of making Shanghai a clean, beautiful, and civilized city.

/6662
CSO: 4008/1110

THE EFFECT OF MAGNETIC FIELD ON ELECTRON COLLISIONS AND THE ELECTRO-CONDUCTIVITY OF PLASMA

Chongqing HEJUBIAN YU DENGLIZITI WULI [NUCLEAR FUSION AND PLASMA PHYSICS] in Chinese Vol 6 No 2, Jun 86 pp 65-69, 80

[English abstract of article by Zhong Yunxiao [6988 0061 7197], et al., of Beijing University, Beijing]

[Text] A general kinetic equation for fully ionized plasma is derived from the Bogoliubov equation, taking account of the influence of magnetic field on the collision term. Using this kinetic equation, the electro-conductivity along the magnetic field is calculated with electron density ranging from 10^{12} to 10^{14} cm^{-3}, temperature of plasma 10^5K to 10^7K and magnetic field up to $9x10^5$ gauss. It is found that the conductivity increases slowly with increase of magnetic field. The increment is about 22.3 percent for a plasma with an electron density of 10^{12} cm^{-3} and a temperature of 10^6K in a magnetic field of $9x10^4$ gauss. Hence, one may conclude that the effect of magnetic field on the collision term in the kinetic equation is not very important, but it could not be neglected in a precise calculation.

/6091
CSO: 4009/99

THE INFLUENCE OF MAGNETIC FIELD ON PLASMA CHARACTERISTICS IN A MAGNETIC MULTIPOLE LINE-CUSP ION SOURCE

Chongqing HEJUBIAN YU DENGLIZITI WULI [NUCLEAR FUSION AND PLASMA PHYSICS] in Chinese Vol 6 No 2, Jun 86 pp 81-86

[English abstract of article by Feng Yucai [7458 3022 2624] of the Space Sciences and Technology Center, Academia Sinica, Beijing]

[Text] The influence of magnetic field on plasma parameters in a magnetic multipole line-cusp argon ion source are studied. It is shown that the electrons in the discharge chamber consist of two components having different temperature Maxwellium distributions when discharge voltage is less than 50V. Low magnetic field has little effect on the movement of ions, and ions flow nearly isotropically from the ion production region within the chamber. However, ions will be confined to some extent when the magnetic field is higher than 900G. In this case, the ion leakage width through a cusp is approximately equal to twice the ion gyroradius.

/6091
CSO: 4009/99

A STUDY ON TIME-SPACE DISTRIBUTION OF PARAMETERS OF TOKAMAK FUSION REACTOR CORE

Chongqing HEJUBIAN YU DENGLIZITI WULI [NUCLEAR FUSION AND PLASMA PHYSICS] in Chinese Vol 6 No 2, Jun 86 pp 87-93

[English abstract of article by Luan Guishi [2940 6311 2514], et al., of the Institute of Plasma Physics, Academia Sinica, Hefei, Anhui]

[Text] This article describes a 1-D transport model for Tokamak fusion reactor core. The model includes α-particle, high energy beam injection and energy loss from bremsstrahlung and cyclotron radiation. Reasonable results of time-space-distribution of parameters have been obtained and are in agreement with the current experiment scalings and INTOR's design. Conditions which affect the results were analysed. These include energy utilization, distribution of α-particles, injection characteristics, confinement and impurity of plasma, initial and boundary conditions, etc.

/6091
CSO: 4009/99

OPTIMIZATION OF TOKAMAK PLASMA PRESSURE PROFILE AGAINST HIGH n IDEAL MHD BALLOONING MODES

Chongqing HEJUBIAN YU DENGLIZITI WULI [NUCLEAR FUSION AND PLASMA PHYSICS] in Chinese Vol 6 No 2, Jun 86 pp 94-101

[English abstract of article by Wang Xiaogang [3769 2556 6921] of the Dalian Institute of Technology, Liaoning, and Shi Bingren [4258 4426 0088] of the Southwestern Institute of Physics, Leshan, Sichuan]

[Text] Under the assumption that the local plasma pressure gradient is limited by high n ideal MHD ballooning modes, the optimized pressure profile is examined for noncircular tokamaks. It is found that the q profile strongly affects the resultant average beta value $<\beta>$, as well as the central beta value β_0 and that the radially decreasing q profile is always favourable for enhancing the beta value. The effects of both elliptical and triangular deformations are analysed and rather stronger stabilizing effect of the latter is found.

/6091
CSO: 4009/99

MEASUREMENTS OF CHARGE EXCHANGE CROSS SECTION FOR FAST HYDROGEN PARTICLE WITH GAS TARGET

Chongqing HEJUBIAN YU DENGLIZITI WULI [NUCLEAR FUSION AND PLASMA PHYSICS] in Chinese Vol 6 No 2, Jun 86 pp 102-106

[English abstract of article by Li Huajun [2621 5478 0689], et al., of the Southwestern Institute of Physics, Leshan, Sichuan]

[Text] Cross sections of electron capture σ_{10} and electron stripping σ_{01} have been measured for fast protons and hydrogen atoms with several kinds of gases. The kinetic energy of passing particles is 20-100 keV, the gases involved are H_2, He, N_2, Ne and Ar. The measurements are made on thick targets. Analysis indicates that experimental error is less than ±20 percent. Good agreement is observed between our measurements and data compiled by C.F. Barnett et al.

/6091
CSO: 4009/99

RAMAN SPECTRA AND SYMMETRY OF $LiZnTa_3O_9$ CRYSTAL

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 5, May 86 pp 391-395

[English abstract of article by Lan Guoxiang [5663 0948 4382], et al., of the Department of Physics, Nanki University, Tianjin; received 22 July 1985; revised 29 November 1985]

[Text] Raman spectra of $LiZnTa_3O_9$ crystal have been obtained for the first time and compared with those of $LiTaO_3$. Rorward-Raman scattering shows that there is no polariton dispersion in $LiZnTa_3O_9$, thus we can conclude that the symmetry of $LiZnTa_3O_9$ crystal is D_{3d} point group. Finally, Raman spectra of $LiZnTa_3O_9$ are assigned and discussed.

/6091
CSO: 4009/85

OPTOGALVANIC SPECTROSCOPY IN AN Eu HOLLOW CATHODE DISCHARGE

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 5, May 86 pp 396-401

[English abstract of article by Jing Chunyang [2529 2504 7122], et al., of the Shanghai Institute of Optics and Fine Mechanics, Academia Sinica; received 22 October 1985; revised 8 December 1985]

[Text] A CW tunable dye laser was used to measure the optogalvanic spectroscopy of Eu. Sixty-five spectral lines were observed, among them 61 are from EuI, and 4 are from EuII.

/6091
CSO: 4009/85

HIGH-EFFICIENCY FREQUENCY TRIPLING OF 1.06 μm LASER RADIATION

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 5, May 86 pp 413-419

[English abstract of article by You Chenhua [1429 2525 5478], et al., of the Department of Optical Instrument, Zhejiang University, Hangzhou; received 17 September 1985]

[Text] In this paper, coupled-wave equations are solved for large signals by means of numerical integration. A numerical method for calculating SHG and THG efficiencies of beams with Gaussian temporal profiles is given. A high-efficiency frequency tripling scheme for low and moderate power levels is presented. With type-I β-BaB_2O_4 crystal used in doubling and type-II KD*P used in tripling, energy conversion efficiencies of THG as high as 41.8 percent have been achieved at an energy level of 365 mJ.

/6091
CSO: 4009/85

STUDIES ON MULTI-PHOTON OPTICAL BISTABILITY

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 5, May 86 pp 427-432

[English abstract of article by Weng Zhaoheng [5040 0340 1854] of the Changchun Institute of Optics and Fine Mechanics, Academia Sinica, Ma Aiqun [7456 1947 5028], et al., of the Harbin Institute of Technology; received 24 January 1985; revised 21 November 1985]

[Text] In this paper a quantum mechanics model for describing multi-photon optical bistability is given. Based on this model, the state equation of multi-photon optical bistability is obtained. The method which for calculating the threshold of multi-photon optical bistability is also given. After analyzing the potential function, we obtain the statics stability criterion and the explanation of switching characteristics. The stable region and the inferior stable region in the bistability characteristic curve are separated. In fact, multi-photon optical stable states are actually multi-photon optical stable-inferior stable states. We also discuss the phase transition problem of multi-photon optical bistability and multi-photon lasers.

/6091
CSO: 4009/85

HOLOGRAPHY OF WIDE ANGLE AND GREAT SCENE

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6 No 5, May 86 pp 433-439

[English abstract of article by Xing Liangling [1630 5328 2733], et al., of the Laser Research Institute, Suzhou University; received 15 October 1985]

[Text] The present work is based upon the teaching materials of experimental holography given by Professor J. Upatnieks used at the Electrical and Computer Engineering Department, Michigan University. After making some improvements in the optical system according the experimental conditions in our institute, we succeeded in taking several holograms of wide angle and great scene of Sozhou garden models (120 visual angle, 250 cm depth and 100 x 250 cm area) and obtained a bright and sharp 3-D reconstructed image. Therefore, this technique provides a cheap and practical method for taking holograms of great visual angle and scene in engineering structures, holographic display, advertisement, artistic photography, data-storage, etc.

/6091
CSO: 4009/85

ELECTRO-OPTICS DEVELOPMENT PLAN APPROVED

OW200527 Taipei CNA in English 0947 GMT 20 Mar 86

[Text] Taipei, March 19 (CNA)--The Executive Yuan has approved a plan to spend NT$2.7 billion (U.S.$67.5 million) in four years for the development of the nation's electro-optics industry, the National Science Council announced Tuesday.

The council said the plan, to begin by 1 July, is the product of more than 100 business leaders, university professors, government officials and specialists, who have spent months working out the details.

Four government agencies will carry out the projects of the development plan. The National Science Council will bear NT$320 million of the expenses involved, the Economics Ministry, NT$1.9 billion, the Communications Ministry, NT$325 million, and the Education Ministry, NT$147 million.

The Science Council said six projects will receive priority:

1) Electro-optic semiconductors: Efforts will be made to expand the market domination rate of locally made electro-optic products and the development of new products.

2) Optical products and equipment: Work will be done to develop higher-level optical techniques and products.

3) Optical information: Emphasis will be placed in the development of optical information products.

4) Optical fiber communication products: Promotion will be made in the upgrading of the application of optical fiber cables in communications facilities.

5) Laser processing: Programs will be carried out to promote the study and application of lasers in industrial products.

6) Electro-optic test and control: Development will be made in the application of electro-optic gadgets in measuring, testing and controlling equipment.

/6662
CSO: 4010/1063

PRC INSTITUTE PLANS TO ENTER PROCESS CONTROL SOFTWARE MARKET

HK050709 Hong Kong HONG KONG STANDARD (BUSINESS STANDARD supplement) in English 5 Feb 86 p 8

[Text] A north China computer research institute is set on turning the tables on the largely Western-dominated computer industry: they plan to break into the sophisticated business of computer software for process control systems.

Located in Harbin, the Computer Application Development and Research Centre of Heilongjiang Province has developed computer software to enable on-line [control] of production processes in the oil, chemical and steel industries.

Representatives from the centre yesterday initialled an agreement with the local China consultancy firm, Kiwa China, to introduce and promote their software on the world market.

An associate research fellow with the centre, and director of the China Optimisation Research Institute, Mr Du Changtai, told THE STANDARD yesterday he was confident they could cut out a slice of the market.

He said that not only is their process control software up to and better than some commonly used systems now available on the market, but it was cheaper and more flexible in its application.

The software is designed to run on microcomputers of the IBM PC variety in a distributed network arrangement which can be tailored to control a range of industrial processes such as oil drilling, oil refining and steel smelting where continuous monitoring is important to efficient production.

Mr Du said that last year their software control system was operating in 18 major industrial sites, including the Daqing Oil Field in the far northeast near the Sino-Soviet border.

Particular problems include not only severe weather conditions. The pump rods in the wells of one of China's largest oil fields go as deep as 2.5 kilometres and are under extreme pressure which is difficult to measure.

But their software and the mathematical models incorporated in its enable interpretation of the signals of various transducers which measure the pressure, and in turn the semi- [automatic] or automatic adjustment of controls.

/6662
CSO: 4010/1062

THREE PRC MINISTRIES COMPETE FOR LUCRATIVE DISH ANTENNA MARKET

HK071005 Hong Kong SOUTH CHINA MORNING POST in English 7 Apr 86 p 10

[Article by K.C. Tsang and Albert Chan]

[Text] A behind-the-scenes race is on among three Chinese ministries battling for the dish antenna market to pick up television signals from satellites and overseas stations.

The three ministries currently producing antennas, which are becoming more and more popular in the U.S. and Japan, are the Astronautics Industry, the Electronics Industry and the Posts and Telecommunications ministries.

Each is competing to sell its products in the international market instead of pooling their resources, said Mr Hu Chuanshui, general manager of the Shanyu Science and Technology Development Co, an offshoot of the Ministry of Astronautics Industry in Shantou.

Mr Hu said the engineers with his ministry had years of experience in military satellites and the television dish for home use was relatively simple equipment.

The Astronautics [?] Ministry set up the company in Shantou Special Economic Zone seven months ago in a bid to push sales to overseas markets.

The satellites measure 6.5 metres in diameter and are produced in the Institute of Radio Technology in Xian, which engaged solely in military telecommunications research until recent years.

But the Shantou company is likely to face stiff competition within China and outside the country.

Though Mr Hu was reluctant to comment on competition among the three powerful Chinese ministries, he acknowledged there was lack of coordination and cooperation in the field.

The Astronautics Ministry target is to sell antenna equipment to Third World countries and to Hong Kong.

Mr Hu said a Hong Kong company is negotiating with the Shantou firm to be its agent for the Chinese equipment.

Mr Hu said the dish will retail around US$14,000 (about $109,000). Hong Kong made alternatives sell for about $45,000.

But Mr Hu said the quoted price is subject to change because market studies are currently being conducted to find out international prices.

He said although the Xian institute can produce dishes in four sizes--three, 4.5, 6.5 and 10 metres in diamter--the emphasis is on the 6.5-metre version because this is the size China and Southeast Asia need to receive transmission from countries like the United States and Australia.

Overseas competition is mainly from the U.S. and Japan and there are plans for cooperation with some of their manufacturers.

Mr Hu said: "We are discussing this with Toshiba from Japan but there may be difficulties in technology transfer because of the competition involved."

So far, the company has sold five dishes to several television stations on the mainland.

They enable the stations to receive clear reception from Central Television in Beijing and transmissions from the U.S. via the Intelsat satellite--as well as from Southeast Asian countries including Thailand, the Philippines, Malaysia, and Indonesia via the Palapo satellite.

The company in Shantou is hoping to transfer part of the assembly line from Xian to the special economic zone.

The main advantage of China-made satellites is the relatively cheap after-sale service cost.

Mr Hu said: "Japan and U.S. equipment may appear to be inexpensive but when it comes to service and repair, it can cost a fortune."

But there are also disadvantages in selling high-tech equipment overseas--as anticipated by the head of another state-run enterprise in Shantou.

Mr Yao Jinzhong, director of Shantou Institute of Ultrasonic Instruments which manufactures ultrasonic testing equipment such as scanners for medical use, said: "If trouble developed with equipment we sold, our engineers would need visas to travel to a customer's country and that could take months for approval."

/6662
CSO: 4010/1062

TECHNOLOGY EXCHANGE MEETING HELD IN GANSU

HK270458 Hong Kong ZHONGGUO TONGXUN SHE in Chinese 1215 GMT 24 Apr 86

[Feature by Tai Wen [0668 2429]: "The First Nongovernment-sponsored Technology Exchange Meeting on the Mainland"]

[Text] Hong Kong, 24 Apr (ZHONGGUO TONGXUN SHE)--It is warm and sunny in April in Gansu. During the first 10 days of April, the "first technology exchange meeting of urban electroplating workers," initiated and sponsored by the Yin Naide Nonmetal Electroplating Research Institute of Suzhou City was held in Gansu. More than 300 experts and scholars of the electroplating circles and electroplating workers of urban enterprises from every part of the country extensively exchanged experience regarding various technical issues at the meeting.

Yin Naide, 46, is well known. During the early 1960's, he studied at Suzhou Industrial Training School. After graduation, he specialized in the research of electroplating and the nonmetal electroplating of plastics, rubber, ceramics, and other materials, and attained many achievements. During the "cultural revolution," due to fabricated charges, he had to give up his speciality and became a jobless tramp living on selling his know-how and labor. During this period, overcoming unimaginable difficulties, he traveled through over 200 cities, nearly 400 counties, 100 market towns, and over 750 scenic spots and historical sites and wrote travel notes of over 2 million words. For this reason, he was described by press [words indistinct] modern Xu Xiake." During travels in Xizang he discovered that the bronze Tathagata statute at Zhashilunbu Temple in Xigaze Prefecture in Xizang is the biggest bronze statute in the world. His discovery attracted attention at home and abroad. In 1984, in view of the development of the urban and township industries and the need for scientific and technological cooperation, this innovative person decided to resume his speciality to apply his scientific and technological knowledge to the four modernization drive. He applied to set up a nonmetal electroplating research institute in his own name. His application was approved by the government departments concerned.

Over the last few years, while further studying the technology of nonmetal electroplating, he has actively provided scientific and technological consultation and services for the urban and township enterprises and has been favorably received by departments concerned in all localities. He firmly believes that the technical forces of the electroplating enterprises set up by townships and towns are very weak. Although they long for the support and assistance of the scientific and technological departments, they do not have the opportunity to attend the academic symposiums and large-scale technological exchange meetings sponsored by the government. Therefore, Yin Naide decided to hold a technology exchange meeting mainly for medium-sized and small electroplating urban enterprises. He hired experts in electroplating from Shanghai, Tianjin, Wuhan, Guangzhou, and other places to be advisers to the technological exchange meeting.

I was fortunate enough to have witnessed with my own eyes the consultation services of this nongovernment-sponsored technology exchange meeting. Under a horizontal scroll reading "Free Technology Consultation Services," there were experts in electroplating from every part of the country serving as advisers to the meeting. Like doctors answering patients' inquiries, they answered people's questions about production technology. At one of the corners of the meeting place there was also an "emergency ward" for holding group consultations about the difficult problems confronting enterprises that need to be urgently solved in production. As the questioners were sincere and the answerers were patient and meticulous, the atmosphere was very harmonious. Dai Zhaowen, deputy director of the Nanjing General Washing Machine Factory and an electroplating engineer, was very busy answering 16 inquiries in a single morning. Within a short period of several days, the meeting offered over 680 consultation services and over 70 manhours at the "emergency treatment" center, and most inquiries got satisfactory answers. The experts from every part of the country also gave a dozen special technological lectures, clearing up some technical problems generally confronting the urban electroplating enterprises and introducing the scientific and technological trends in the electroplating industry at home and abroad. These lectures were geared to actual conditions and were well received.

Yin Naide told me that in the past, the commodity value of science and technology was not recognized on the mainland and scientific and technological achievements were often readily and unconditionally transferred. This is certainly wrong. However, it is also undesirable to go to the other extreme to guard and conceal some general technology which can hardly be called advanced and to charge others very high prices. The purpose of our holding this technology exchange meeting is to check this tendency, bring into play the spirit of mutual support and assistance, and make more urban electroplating workers improve.

Fang Jingli, an associate professor at the Research Institute of Applied Chemistry of Nanjing University, said that in the future the meetings of our scientific and technological circles can be both government-sponsored as well as nongovernment-sponsored. The purpose is to exchange technology. Although this meeting was not sponsored by the government, people feel very rewarded and that this was a worthwhile trip.

/9738
CSO: 4008/1108

BRIEFS

ADVANCED DOCUMENTAL DATA BASE--Beijing, 20 Jun (ZHONGGUO XINWEN SHE)--China's largest and most technologically advanced documental data base has been completed and put to use by the Science, Technology, and Industry Commission for National Defense. Today's JIEFANGJUN BAO says: The base has a huge storage capacity, complete data, and advanced index-selecting means. It has 17 sub-bases, including foreign data, strategic data, and files data sub-based. It stores more than 5 million pieces of documental data and a large amount of contents listings, cards, and indices. The base also establishes a network connecting 40 computer terminals set up by scientific establishments in 20 cities, including Beijing and Shanghai, and a multi functional modern data management system. The completion and use of the base indicates that the Chinese Army's library and information work has made fairly great progress. [Text] [Hong Kong ZHONGGUO XINWEN SHE in Chinese 1120 GMT 20 Jun 86 HK] /9738

USE OF BIOLOGY IN FORENSICS--Hufei, 8 Jul (ZHONGGUO XINWEN SHE)--China's first base for specially manufacturing biological products used in criminal investigations has been established in Huaibei City in Anhui Province. By early July, the base had manufactured 17 types of antiserum for public security and judicial organs, and colleges as well as universities concerned in 27 provinces, cities and autonomous regions. Making use of antiserum to examine and identify bloodstains, sperm spots and hair may quickly and accurately detect individual criminals, confirm crimes and negate suspicion, and provide scientific evidence for investigations and trials. Making use of antiserum to investigate criminal cases is a new project studied and developed by medical jurisprudence both at home and abroad. In 1981, Wang Jingcai, an assistant engineer from a research office under the public security bureau of Huaibei City, successfully manufactured for the first time, three types of high-quality antiserum. Accurate and reliable results were obtained after their application in actual cases. In 1985, the ministry of public security decided to expand the research office into a base for manufacturing biological products. Various facilities and equipment have been improved. The base has been assigned the task of studying various kinds of antiserum products. [Text] [Hong Kong ZHONGGUO XINWEN SHE in Chinese 1234 GMT 8 Jul 86 HK] /9738

CSO: 4008/1108

END